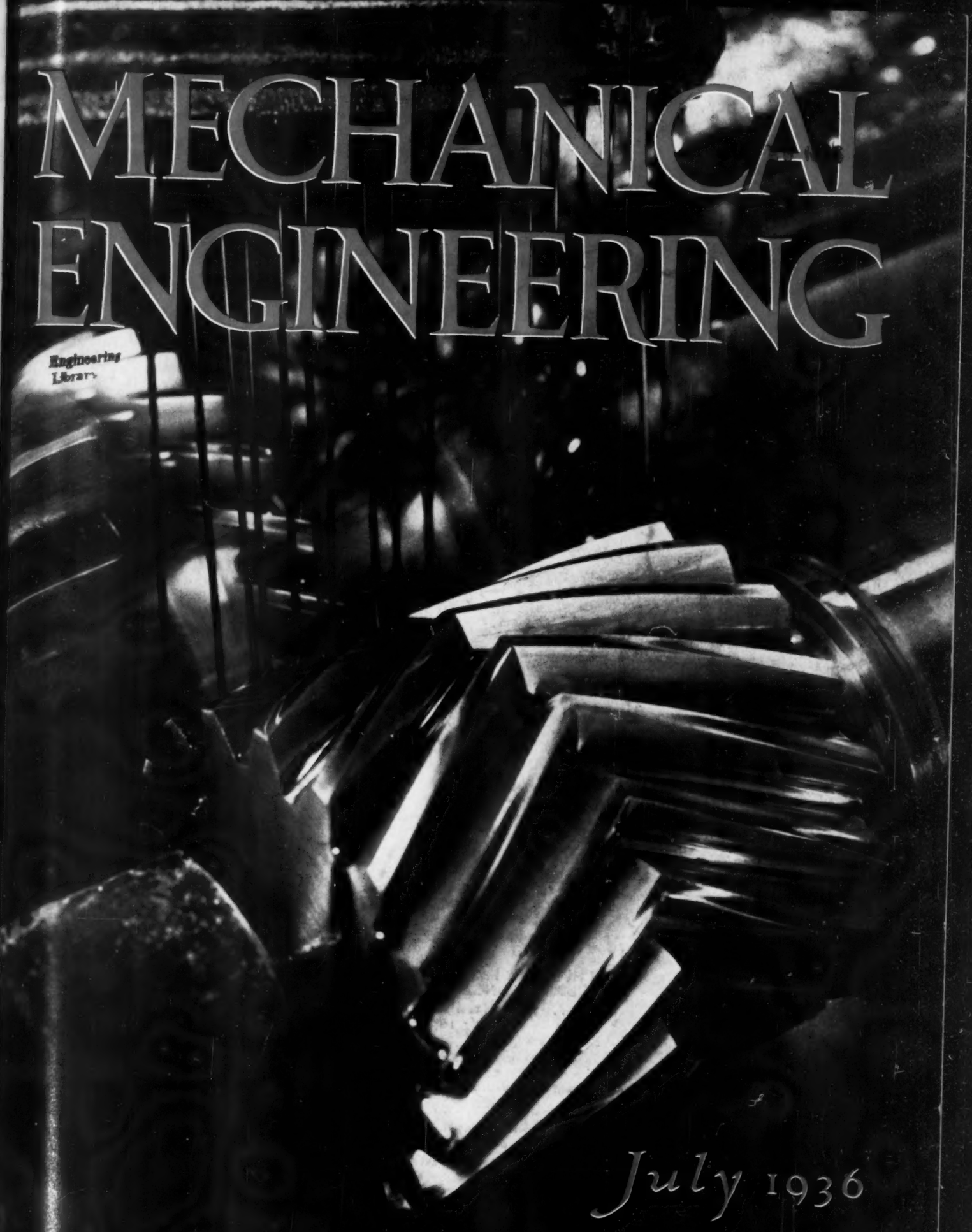
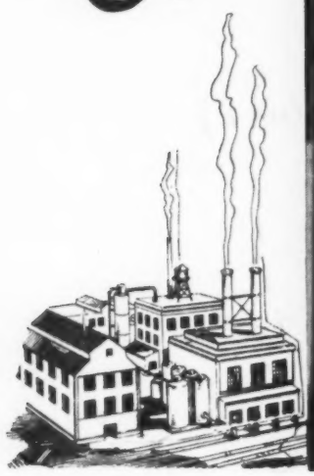
MECHANICAL ENGINEERING

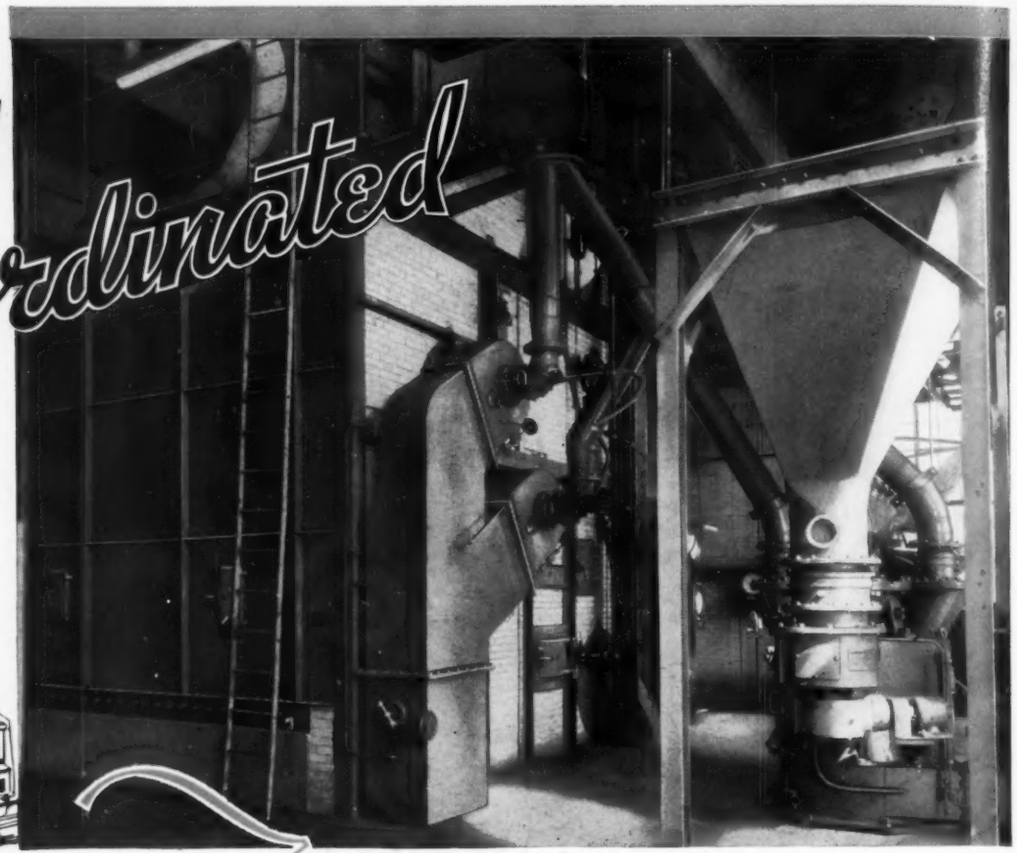
Engineering
Library



July 1936

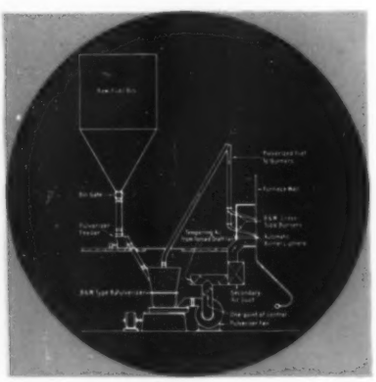
Fully Coordinated





The B & W DIRECT FIRING SYSTEM

The photograph above shows the complete Babcock & Wilcox Direct-Firing System applied to a modern unit of moderate capacity . . . a compact, accessible, and easily-operated arrangement of equipment. An arrangement drawing of the system for units of larger size is shown below.



THOROUGHLY RELIABLE NO INTERRUPTIONS IN SERVICE

. . . steady, controlled flow of coal from bin to burners . . . no hanging up.

. . . records show pulverizer 100 per cent available for as long as 42 consecutive months in unusually high load-factor service.

EASILY OPERATED

. . . single control for pulverizer, feeder, and primary air.

. . . constant-speed motor drives for pulverizer, feeder, and fan.

UNUSUALLY RESPONSIVE TO SUDDEN CHANGES IN LOAD

. . . pulverized-coal firing, like oil and gas, is inherently responsive to load changes.

. . . this responsiveness increased by automatic utilization of coal storage capacity of the pulverizer.

DESIGNED FOR SAFE OPERATION

. . . all parts designed to withstand 200 lb. per sq. in. internal pressure.

. . . rich mixture for safe starting; no puffs or flare backs.

. . . automatic burner lighters for additional safety in starting.

SUSTAINED HIGH EFFICIENCY

. . . high fineness of coal and proper mixture with air at all ratings.

. . . fineness not affected by wear of grinding parts.

. . . high fineness with any grade of coal assured by ball-bearing grinding principle.

MAINTENANCE LOW CHIEFLY CONFINED TO GRINDING PARTS OF PULVERIZER

. . . proper mechanical design, correct grinding principle, best selection of metals, and moderate speed operation assure low maintenance.

. . . records show indicated life of grinding parts as high as 40,000 hours of actual operation.

. . . pulverizer fan handles only clean air.

For complete information on these and other advantages of the B&W Direct-Firing Pulverized-Coal System, address The Babcock & Wilcox Company, 85 Liberty Street, New York.

BABCOCK & WILCOX

G-82

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 58 NUMBER 7

Contents for July, 1936

THE COVER . . . . . *Close-Up of a Sykes Herringbone-Gear Generator*
MODERN TOLERANCE REQUIREMENTS AND THEIR SCIENTIFIC DETERMINATION . . . . . *Hilding Tornebohm* 411
MECHANIZATION OF THE POTASH MINES IN NEW MEXICO . . . . . *H. I. Smith and R. V. Ageton* 418
GEAR NOISE—CAUSES AND CORRECTIONS . . . . . *W. E. Sykes* 423
PROCESS INDUSTRIES AND RURAL STABILITY . . *W. R. Woolrich* 427
REVIEW OF AERONAUTICS:
AERONAUTICAL METEOROLOGY . . . . . *J. E. Woodman* 431
AERODYNAMICS . . . . . *A. L. Klein* 432
AIRPLANE DESIGN AND CONSTRUCTION . . . . *R. M. Mock* 433
AIRCRAFT POWER PLANTS . . . . . *C. F. Taylor* 435
MATERIEL DIVISION ACTIVITIES . . . . . *A. W. Robins* 436
BUREAU OF AERONAUTICS, U. S. NAVY . . . . . *E. J. King* 439
RADIOGRAPHIC INSPECTION OF WELDED REFINERY EQUIPMENT . . . . . *H. R. Isenburger* 442
THE FEDERAL SOCIAL-SECURITY PLAN . . . . . *John Shute* 447

EDITORIAL 409
ENGINEERING PROGRESS 449
LETTERS AND COMMENT 458
A.S.M.E. BOILER CODE 461
REVIEWS OF BOOKS 462
WHAT'S GOING ON 464

DISPLAY ADVERTISEMENTS 1
ABOUT OUR ADVERTISERS 16
INDEX TO ADVERTISERS 36
PROFESSIONAL SERVICE 33
CLASSIFIED ADVERTISEMENTS 34

OFFICERS OF THE SOCIETY:

WILLIAM L. BATT, *President*

W. D. ENNIS, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATION STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

COMMITTEE ON PUBLICATIONS:

S. W. DUDLEY, *Chairman*

G. F. BATEMAN M. H. ROBERTS

W. F. RYAN C. B. PECK

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

W. L. DUDLEY, SEATTLE, WASH. A. N. GODDARD, DETROIT, MICH. L. S. MARKS, CAMBRIDGE, MASS. J. M. TODD, NEW ORLEANS, LA.

Junior Members, O. B. SCHIER, 2D, AND L. N. ROWLEY, JR.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879 . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921 . . . .Copyrighted, 1936, by The American Society of Mechanical Engineers.Member of the Audit Bureau of Circulations.

Gerald Young

Grinding a Steel Gear Blank

VOLUME 58
No. 7

MECHANICAL ENGINEERING

JULY
1936

GEORGE A. STETSON, *Editor*

The Empire Builder

IT was only about a year ago that John Hays Hammond's two-volume story of his life—reviewed in our September issue by Professor Roe—appeared and took us back to earlier and more exciting days of empire building when engineering had a geographical frontier. Fortunately for engineering biography, this work was finished and published before death, which took Mr. Hammond in June, intervened.

Thousands of steady-going citizens—many of them engineers—had, when young, aspirations for the same sort of life of romantic adventure that Hammond experienced in South Africa. And romanticists among them possibly still sigh—secure in their own homes—for that vanished age of empire building and the frontier.

But only the geographical frontier has vanished, as Past-President Flanders asserted in his address last December, "New Pioneers on a New Frontier." Such qualities as Hammond displayed were compelled by circumstance and the age in which he lived to develop along the lines that gave his individuality, resourcefulness, and driving force of accomplishment a chance to operate in a pioneer country against natural and political odds. These same qualities, appearing today in a man of equally strong character but living in the highly complex society of an industrialized nation, would provide raw material for leadership and accomplishment that the world greatly needs. Empire building is no more. Today we need to consolidate the gains of technological progress and weld together numerous groups of persons and nations into a peaceful, productive, and tolerant social organism. Men of Hammond's strong personality are needed for such jobs. In performing them the satisfactions are great, for the beneficiary is civilization itself.

Precision in Gaging

WATT once wrote, with an enthusiasm unusual in a Scot, of the achievement in precision boring by which Wilkinson had made a cylinder "true within the thickness of an old shilling." In the century and a half of machine development that has transpired since that time, both precision in machinery and in methods of measurement have increased almost unbelievably.

As is natural in such related techniques, precision in machinery and in measurement and gaging have suffered cyclical developments, slightly out of phase, as first one and then the other forges ahead. Fifty years ago, as we have often recalled to our readers, George M. Bond worked on measurement because methods of manufacture were capable of greater precision than gaging devices, and even the fundamental units of measurement, could then reliably detect. Out of his work grew the gage department of the Pratt and Whitney Company for which for many years he was responsible.

Today, as Mr. Törnebohm reminds us in the excellent Calvin W. Rice lecture published in this issue, the accuracy of machine work, so essential for the mass-production industries, has exceeded the ability of our instruments and techniques to measure it conveniently and practically. Thus is opened up a new development in gage design, manufacture, and use to which Mr. Törnebohm's lecture makes significant contributions. Mr. Törnebohm has, in effect, issued a challenge to manufacturers in this country to improve their gaging techniques, and it will be disappointing if great progress in this field does not result.

Not the least important feature of the Calvin W. Rice Memorial lectures is the opportunity it affords of bringing to this country experts from overseas who have something to contribute to our engineering thinking. It is gratifying to contemplate how, in these lectures, the progressive spirit of Calvin W. Rice continues as a vital factor in bringing together men of different nations for the common benefit of the engineering profession.

Noise Reduction in Machinery

TWO contributors to this issue, Mr. Sykes and Doctor Abbott, draw our attention to the subject of noise—Mr. Sykes in a very practical article on the reduction of noise in gearing, and Doctor Abbott in a letter commenting on the situation as regards noise and noise measurement in general. Both remind us that this important but little heeded subject is one of particular interest to designers, as the source of much noise lies in the design, construction, and operation of machines, which may be skillfuly and intelligently, or heedlessly, done. Parenthetically, let us confess that it was a happy but unpremeditated circumstance by which a close-up of one of Mr. Sykes's gear-cutting machines came to adorn this month's cover.

As companion reading with these contributions, the April issue of *Industrial Standardization*, the official bulletin of the American Standards Association, is recommended. Here are three articles telling about the

broad program of the Sectional Committee on Acoustical Measurements and Terminology, the Subcommittee on Noise Measurements, and the Technical Committee on Sound Levels and Sound Level Meters.

As we have repeatedly asserted in these columns, noise considerations in the design of machinery are destined to be given closer attention in the future. Just as safety features are now considered in the design of a machine and worked into it instead of being hung on as a belated afterthought following some serious accident, so noise reduction and elimination will become factors for study, with features for accomplishment entering as basic elements of design. Lubrication and safety are appearing in textbooks on machine design and in specifications for machinery. Noise reduction will quickly receive similar attention. MECHANICAL ENGINEERING is glad to have an opportunity to aid in calling attention of engineers to developments in noise reduction and elimination.

Junior Organization at Providence

MANY times in these pages attention has been directed to the junior engineer and his professional development. No need exists for repeating the dangers and difficulties of those early years after graduation during which the young engineer finds himself and fits himself for mature work in the profession. So important are these years, as every one who has experienced them will attest, that one of the four major committees of The Engineers' Council for Professional Development, that of which Gen. R. I. Rees is chairman, is devoted to their problems. What progress and practical contributions this committee has already made have been reported here from time to time.

This spring the E.C.P.D., through General Rees's committee, cooperated with the Providence Engineering Society in its junior-development movement with results that are gratifying and significant. As plans mature and hopes are realized, other centers of the engineering profession will try similar experiments and Providence will be added to the list of places where young engineers find opportunities to engage in organized activities designed to benefit their professional and social development.

Following General Rees's exposition of the junior movement, a committee of twelve prominent engineers and educators of the Providence Engineering Society, with Mr. Alton B. Chick as chairman, distributed a preliminary questionnaire to 600 engineers not more than five years out of college and to other young men definitely following lines of engineering activity. To initiate an organization of these men, a selected group of 25 junior engineers was appointed who chose as officers Robert Anthony, Jr. (Yale) chairman, Roger P. Condon (M.I.T.) vice-chairman, and John R. Pearson (R. I. State) secretary-treasurer.

In discussions relating to a program for the junior engineers it was decided that personal contacts and self-expression were the two chief benefits to be derived from the proposed activities. Replies to the questionnaire numbered 151, and were classified as follows: (1) Interested in papers by junior engineers 129; (2) interested in group discussion 145; and (3) interested in formal study 136. Thirty-seven topics for group discussions were voted on, of which the most popular were: (*a*) Production control and time study 39; (*b*) air-conditioning 26; (*c*) personnel relations 26; (*d*) marketing 14. The most popular of the 35 suggested topics for formal study were: (*a*) Business law 54; (*b*) public speaking 43; (*c*) cost accounting 23; (*d*) differential equations 14; and (*e*) power-plant subjects 8.

On April 20, for the first general meeting, 250 juniors turned out. General Rees spoke for the E.C.P.D. on the proposed plan; and at a subsequent meeting on May 4 four groups, each with a junior engineer as a group leader, were set up: A management group, interested in manufacture and managerial technique, is headed by Graydon L. Abbott; the machine-design group, by Harold S. Sizer; the power group, concerned with steam plants, Diesel power, and general plant engineering, by Norman Bampton; and the fourth group, containing those who wish to discuss the general economic background of the Providence industrial area, by Roger P. Condon. Other groups will be organized as need arises.

Because of the great interest in the law, it is proposed to engage next fall the services of a qualified lawyer to give a series of lectures on business law, including contracts and specifications.

Twenty-five men, under the leadership of Ogden Sawyer, are contemplating courses leading to the degree of master of engineering, and it is hoped that arrangements toward this end may be perfected with Brown University.

In building up discussion, members of the groups will be assigned topics or projects. For example, the machine-design group plans to commence a study of springs and their characteristics and uses in machines. The power group hopes to assemble and tabulate useful information on combustion and air conditioning. The economic group will examine such a project as "What business to embark on in Rhode Island if $100,000 were made available with which to do it." It is planned to develop this project to include other groups because, for example, if a manufacturing enterprise is decided upon as the solution, construction engineers may study the building problem, power engineers the power equipment, machine designers the design and adaptation of machinery, and the management group personnel, operation, and cost estimation.

If the plans of the Providence junior engineers are reasonably well carried out, an interesting experiment in cooperative post-collegiate study will result, with benefits to the individuals engaged in it that will have social and cultural, as well as technical and professional, value. Moreover, the E.C.P.D., which is an agency for getting engineers and engineering organizations to develop themselves and the profession, will have demonstrated the practicability of some of its ideas.

Modern TOLERANCE REQUIREMENTS *and Their* SCIENTIFIC DETERMINATION

By HILDING TÖRNEBOHM

A. B. SVENSKA KULLAGERFABRIKEN, GOTEBORG, SWEDEN

IT IS now about thirty years since the mechanical engineers of the world were startled by the accuracy obtainable in the new Johansson blocks, which opened for the whole industrial world the possibility of accurate measurements to a degree of precision which before this time had been considered impossible. At the time these remarkable blocks were invented 0.001 in. was considered an extremely accurate measurement. Today we speak of 0.0001 in. and less with a general understanding of what it may be. It has been this development in the technique of measurement which has made possible mass production and complete interchangeability of parts. As a specific example, what would the automobile industry be today without the possibility of part interchangeability? We take this matter of interchangeability so casually that we forget the difficulties which would exist if the possibilities of accurate measurements were nonexistent.

HILDING TÖRNEBOHM

CALVIN W. RICE MEMORIAL LECTURER

The machine-tool industry is to be complimented on the manner in which it has kept up with the necessity for accurately machined parts. Without its help and development, mass production, with its extreme accuracies, would be practically impossible.

We have now come to a point where the possibility of making accurately the required parts actually exceeds our ability to measure them with the proper degree of precision. The reason for this is that the development of measuring equipment, such as plug gages, snap gages, micrometers, and bore gages, which are generally used in industry today, has not been improved to any great extent over the past 25 years, although, of course, such gages are today built of better material, with greater accuracy, and generally have a much longer life. The point I should like to bring out, however, is the fact that, with few exceptions, the measuring equipment in the average plant of today is far inferior basically to the machine equipment. We may say to ourselves that our measuring equipment is entirely satisfactory. I am fully convinced, however, that many of the apparently inexplicable failures which occur are due, to a smaller or larger extent, to the imperfections which are not readily determined by our average measuring devices.

Before we go into a discussion on the actual characteristics of measurements, I should like to digress for a moment and discuss generally the International Standards Association, with specific reference to its Committee No. 3 on Limits and Fits, of which I have had the honor to be a member since its inception in 1928. When we met originally the difficulties in coming to a common understanding seemed practically insurmountable. In the first place, we spoke different languages and we had no common understanding of the various terms which should be used. Obviously, there was absolutely no basis for agreement as to what was actually required with regard to fits and tolerances. The committee itself could not begin to function until there was some acceptable solution for the basic problems which were involved. Only then was it possible for each of the individual members to determine for himself the correctness of the many fundamentals that were discussed. It must also be remembered that in a group as large as the International Standards Association, where each member has equal rights, the final conclusions reached must have been absolute facts or they never would have been agreed upon unanimously. What I shall discuss in my paper are not alone my own conclusions, but are the conclusions based upon eight years of intensive work on facts obtained by experts from many countries.

It was necessary for us to determine the length of the meter, and in connection therewith, the length of the inch. As is well known, the meter was defined at the Conference Générale des Poids et Mesures in 1927 by the wave length of red cadmium, measured with an interferometer. It was also necessary to

The Third Calvin W. Rice Memorial Lecture, delivered at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

determine a reference temperature, which is now 20 C or 68 F, the figure which has always been used in this country. All of the countries of the world, even England and France, have adopted this temperature.

For the first time it was then possible definitely to determine the precise relationship between the inch and the meter, and, as you know, the relation is 25.4 mm exactly equals one inch. This, and other points of agreement, are naturally of fundamental value. Equally important, however, are such considerations as the wear of the gage, the amount of wear permissible in a gage, where the wear of the gage shall be located, the manufacturing tolerances on the gage, the accuracies and the method of measurement—all of which are fundamental in their scope and vital in their significance.

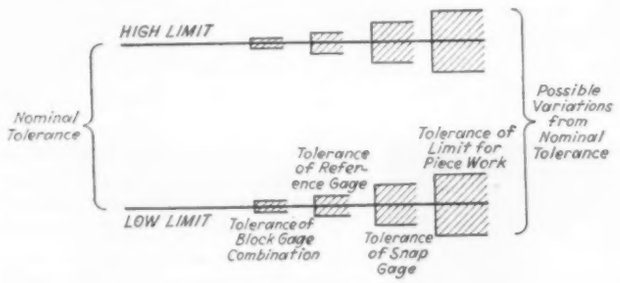


FIG. 1*a* PRESENT SYSTEM OF TOLERANCES COMMONLY USED

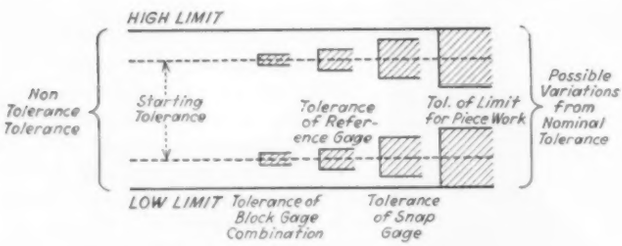


FIG. 1*b* FRENCH "SYSTÈME DE L'INTRANSIGEANCE"

INACCURACIES IN GAGE MANUFACTURE

From checking a number of gages we knew that inaccuracies existed in the products of European gage manufacturers, and in the preparation of this paper it seemed to me desirable to determine whether such inaccuracies might also be present in gages made in the United States. A number of gages were obtained from the best known manufacturers in this country and found to be excellent. Nevertheless, they exhibited the same characteristic errors. The overall variations on the part of the various gage manufacturers was as much as plus and minus 0.0001 in., both on the maximum and minimum sides, and, what is most important, no allowance was made for wear. Similarly, in the case of snap gages, the variations were 0.0001 in., and no allowance was provided in the adjustments to the actual weight of the snap gage itself, the effect of which may be to change the actual dimension by as much as 0.0002 in. in a gage of ordinary size. We must, therefore, conclude that the same conditions which have existed in Europe also exist in this country.

Let us, for a moment, get away from theory and consider an actual case as it exists in a manufacturing plant. If we have a shaft which on the drawing shall be within a tolerance of 1.5748 in. maximum and 1.5744 in. minimum, what shall we actually obtain? In the first place, let us consider measuring this shaft with a micrometer. We know that the micrometer will be handled differently by different workmen; that different pressures will be applied; that there may be variations between two micrometers; and that there may be wear in the micrometer screw itself. All of these factors will tend to give inaccurate readings, and I am safe in saying that the variations in the readings of two good inspectors with two different micrometers will vary from plus or minus 0.0001 in. to plus or minus 0.0002 in. Even with so broad a range, the inspectors must be of more than average ability. If, now, we consider stationary instruments, such as dial indicators, the accuracy will not be better unless special care is taken. There are many possibilities of error, i.e., errors in the indicator itself, and in the adjustment, pressure variations, and internal friction in the indicator. While no generalization can be made concerning these errors, nevertheless they may be of a large magnitude compared with the present small tolerances.

INACCURACIES IN USE OF GAGES

When we use snap gages an entirely new set of problems arises whether these gages are purchased from master gage builders or whether they are made by the user himself. There are, surprisingly, a number of complex questions such as where shall the limits of the wear apply, what shall be their range, what shall be the actual shape and finish of the measuring surface, and how shall the gages be handled. It is remarkable, but, nevertheless, a fact, that there are variations in snap gages due to a number of conditions which are uncontrollable in practice, affecting in turn the correct measurement of the piece involved.

If we have a production problem involving the measurement of a piece having a tolerance of a given amount, there is a possibility of obtaining a set of actual measurements quite different from the originally prescribed tolerances. Let us analyze what may occur by referring to Fig. 1*a*. We shall assume that we desire a particular piece to have an upper and lower limit as shown by the heavy line. Obviously, the first step is the determination of these measurements by block gages that have a very limited amount of error. In transferring the measurements to the reference gage, we have additional and larger inaccuracies. Another transfer, to the snap gage, gives a still greater and additional variation in the high and low limits. And finally, there is the check of the workpiece by the operator, which in turn results in still larger variations. The degree of *the tolerances on the tolerances on the tolerances*—if I may be permitted to use this phrase—is roughly indicated in the figure. If we are to maintain accurately the established tolerances, then quite a different procedure of measurement would be required, see Fig. 1*b*. Such a system is what in France is known as the *Système de l'Intransigeance*, which has always been the preferred system in that country.

It will then be necessary for us to begin with an entirely different set of starting tolerances on the block gages to obtain finally a variation not in excess of the established and required tolerance. Obviously, this would require extremely accurate original tolerance if indeed the degree of variation at the various steps were actually known, which is obviously quite unlikely. Furthermore, consideration must be given to the degree of wear which even tends to decrease the starting tolerance in comparison with the prescribed tolerance. It is for this reason that the International Standards Association has found the necessity for actually providing some tolerances on the tolerances, the magnitude of which has been definitely established, depending upon the characteristics of accuracy required. This approved system is familar to engineers through official American publications.

Quite aside from the errors of transference, we have the

following errors, all of which are important in the consideration of actual measurements:

1 Temperature errors.
2 Errors caused by material stresses in the workpiece.
3 Errors caused by variations from true shapes.
4 Errors caused by variation in the actual surface conditions.
5 Errors caused by imperfections in the tools for measuring the factors essential for the correct judging of fits.

Items 1 and 2 require little, if any, explanation. It is well known that temperature variations for small pieces can usually be disregarded, but when large pieces are involved, we must take these temperature variations into consideration. In spite of this knowledge we frequently forget the problems arising from materials having different coefficients of expansion. Aluminum, for example, has approximately twice the expansion of steel, and if the workpiece is of aluminum and the measuring device of steel, as is most common, errors will arise unless care is taken to measure the workpiece at the established reference temperature.

ERRORS DUE TO MATERIAL SURFACES

As for errors derived from material stresses, again we all are familiar with the results obtained in the hardening of large rings, as for example, in bearing raceways. Their change in shape must be considered or accuracies cannot be maintained. We age castings to prevent warping and deformation caused by material stresses. We are all familiar with the problem surrounding the proper hardening of gears to prevent warping and so eliminate noise. We must make allowance for these material stresses which tend to throw the workpiece out of the desired shape and tolerances.

Geometrical errors, which in German are known as *makrogeometriche Fehler*, present no difficulties from a theoretical viewpoint. However, in actual practice, there are often errors due to the imperfection of measuring equipment which does not detect these variations. Out-of-roundness, tapers, barrel shapes, and bellmouths are common examples of geometrical manufacturing errors, the difficulty of detection depending upon the magnitude of the error from the true form or the design and accuracy of the measuring equipment. This condition of *makro* errors often presents difficult problems from a gaging point of view. Let us consider a bore and a shaft. We can readily obtain an incorrect determination of actual clearances if we consider only the maximum and minimum diametric dimensions of the hole and the shaft. If clearance is defined as the amount of possible radial movement of the shaft in the bore, then it is obvious that this clearance can never be smaller than the difference between the inscribed circle in the bore and the circumscribed circle of the shaft. It is also obvious that the maximum clearance can never be larger than the difference between the largest diametric measurements in the bore and the smallest diametric dimensions of the shaft.

Therefore, with a bore one must consider the inscribed circle and the greatest existing diameter, and with the shaft the circumscribed circle and the smallest existing diameter, in order to avoid imperfections due to geometrical errors.

Next we must consider the usually undetectable errors which, again referring to the German, are known as *microgeometriche Fehler*, or *micro* errors. By this we mean those errors due to variations in the surface conditions, or surface "skin." The importance of good surface is well known in the United States, and I think the engineers in this country are to be complimented on the investigations which have been conducted here and recorded in MECHANICAL ENGINEERING, the *S.A.E. Journal*, the *A.S.A. Bulletin*, *American Machinist*, *Machinery*, and other similar publications. The studies of R. E. W. Harrison, E. J. Abbott and F. A. Firestone, R. C. Deale, John Gaillard, R. T. Kent, G. B. Sawyer, and A. E. White, all American engineers, also Professor Schmaltz and Professor Berndt, of Germany, are scholarly investigations on surface conditions. A specific case in point is the influence on the surfaces where interference fits are concerned. If the surfaces are irregular with a great number of micro errors, as is indicated in Fig. 2*a*, we know that the resultant interference fits must be appreciably increased as compared to surfaces which are smoother or more regular, Fig. 2*b*. Thus the engineer must concern himself not only with the degree of the interference fit but also with the condition of the surfaces which are to be fitted. For clearance fits the surface is of equal importance in order to obtain the proper clearance and a minimum of wear.

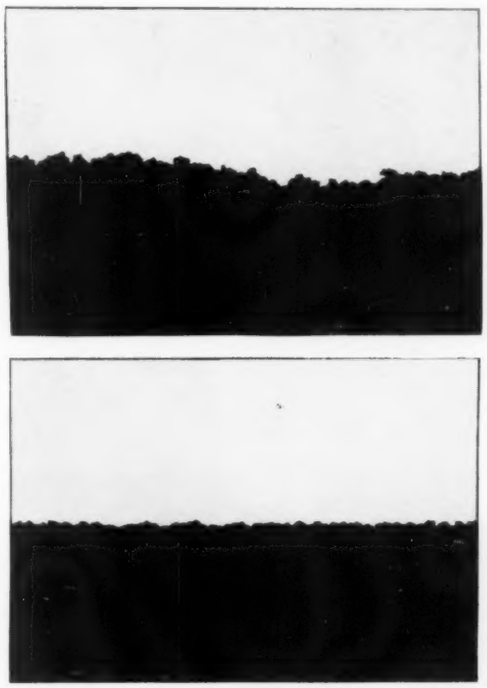


FIG. 2 PHOTOMICROGRAPHS OF SURFACE CROSS SECTION × 800
(Fig. 2*a*, above, ground surface. Fig. 2*b*, below, polished surface.)

MEASUREMENT OF SURFACE IRREGULARITIES

What shall we use as a measure on a workpiece with a certain degree of micro errors? In my original investigations I determined that a study of the measurements of surface conditions was of extreme importance to determine the actual measurements with the desired degree of accuracy. In these studies I found that the measuring pressure, together with the form or contour of the measuring points, was of extreme importance, and far greater in its significance than I at first expected. Any scientific measurements will consider the pressure between measuring parts and the workpiece as zero. As this cannot be done except by actual calculations, which are too complicated to be followed in actual practice, and also impossible when micro errors exist, it seemed necessary to develop a surface-measuring device that would take into consideration the measuring pressure and contours of the measuring parts before any further investigation of measurements themselves was possible.

According to Hertz the approach between two bodies subjected to a force normal to their contacting surfaces is calculated according to the formula

$$\delta = \frac{K}{\pi\mu}\sqrt[3]{\Sigma\rho}\left[\frac{3}{8}P(\vartheta_1 + \vartheta_2)\right]^{\frac{2}{3}}$$

In this formula δ is the approach between the bodies; $\frac{K}{\pi\mu}\sqrt[3]{\Sigma\rho}$ are quantities depending on the radii of curvature of the bodies.

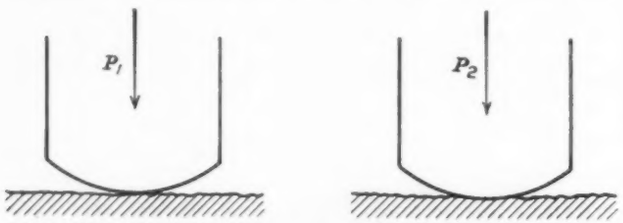


FIG. 3 MEASURING POINT IS PRESSED INTO SURFACE OF WORKPIECE HAVING "MICRO" ERRORS
(P_1 = small load; P_2 = measuring load.)

P is the load; and ϑ_1 Hertz's constant for the contact point, the value of which is calculated according to formula $\rho_1 = \frac{4}{E_1}\frac{m^2-1}{m^2}$ in which E_1 is the modulus of elasticity for the contact point; m the Poisson constant, ϑ_2 the corresponding constant for the workpiece; and, therefore, $\vartheta_2 = \frac{4}{E_2}\frac{m^2-1}{m^2}$; where E_2 is the modulus of elasticity for the workpiece. This formula is correct for surfaces of best possible smoothness, such as the surfaces of gage blocks. If the surface is less perfect, it will be seen that the only factor which will be modified is ϑ_2, which will, of course, have another value. The poorer the surface, the greater must ϑ_2 be, since δ increases with the surface irregularity. If it is assumed that ϑ_2 for the working surface is greater than ϑ_2 for the perfect surface by a factor $1/\Theta$ then Θ will express the quality of the surface. When $\Theta = 1$, the surface is ideal and the quality of this surface may be expressed as a percentage and will then be 100 per cent. The poorer the quality of the surface, the less will be Θ. The percentage figure will fall and the surface quality can be expressed as a percentage of that of the gage block by figures such as 75, 60, 50, 30, or 20 per cent. It is clear that this percentage directly expresses the strength quality of the surface layer, since Hertz's constant is a function of Poisson's constant and the modulus of elasticity of the material, assuming that Poisson's constant does not change, or in other words that it is the same for the surface as for the homogeneous material.

Fig. 3 is a sketch showing in an exaggerated manner what will happen when a measuring point is pressed against a surface with micro errors. P_1 is a small load slightly above zero and P_2 is a greater load, but still not so large but that the material stresses will be well within their elastic limit for both measuring point and workpiece. It is obvious the greater the micro errors, the greater will be the penetration.

SURFACE-TEST INDICATOR

Fig. 4 shows a photograph of the apparatus which I have developed for practical use. It consists essentially of an indicator, the plunger of which has a movement of only 0.00004 in. The indicating device is first set under a load of approximately one-half pound. To obtain a movement of the plunger of 0.00004 in., an additional load is imposed, which load is dependent upon the surface condition and measures the surface directly. In Fig. 4, the instrument is adjusted with the initial load of one-half pound, and the pointer is at the right. Fig. 5 shows the measuring load applied with the pointer to the left indicating a movement of the plunger of 0.00004 in.

Fig. 6 shows seven steel disks which are made of different alloys, hardened and unhardened. As is seen from the illustration, all appear to have different surface finishes. The value of P_2 load varies from 700 g for the best surface—a well-polished surface—to 200 g for a turned surface. It is of special interest to observe that the measurements are independent of the hardness of the material and depend entirely upon the surface conditions.

The new principle just described opens the possibility to a new method of determining surface finishes, and it is hoped that this principle may be utilized in addition to, and as an aid to, the already existing instruments for the determination of surface finishes.

In order to obtain uniformity in measurement results in one factory as compared to another, we have shown that there are

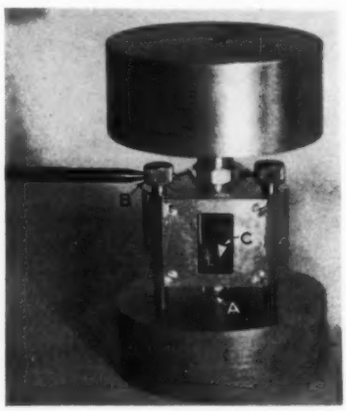


FIG. 4 SURFACE-TEST INDICATOR
(Screw *B* adjusts position of measuring point *A* relative to the indicator body, so that the pointer *C* is at the right side.)

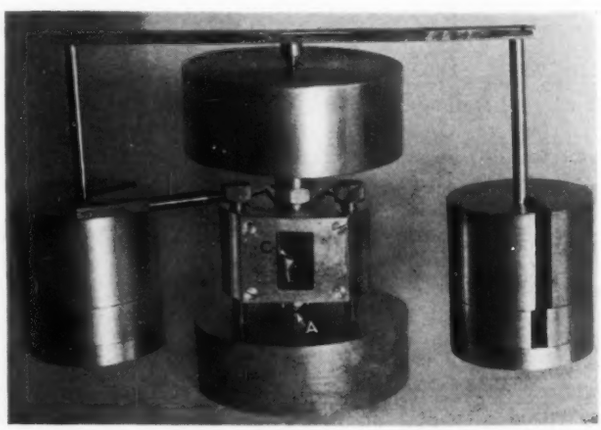


FIG. 5 SURFACE-TEST INDICATOR
(With additional load the pointer *C* moves to the left, whereby point *A* has penetrated by 0.00004 in. The smoother the surface the more load can be applied.)

micro errors, and, due to them, false measurements. The conclusions, therefore, at which we must arrive in dealing with the matter of measuring errors are that standard methods must be established which will include the standardization of:

(1) Measuring pressures
(2) Measuring points when using indicators
(3) Characteristics of the various types of gages themselves.

So far I have discussed only the errors that may arise, and the question can naturally be asked, "Is there *any* proper type of measuring equipment and should not all present equipment be discarded?" Naturally, such a thought is farthest from my mind. I do think, however, that improvements can be made both in the present measuring equipment and in its method of use.

IMPROVEMENTS IN GAGES

As to the proper type of measuring equipment, I am of the opinion, if I may use the experience of our own factory, that a combination of various types of measuring instruments will give the most satisfactory results. In our factory, for example, we use both dial indicators and fixed gages for production.

Dial gages are easy to read and are inexpensive to use, and the problem of wear may be disregarded. However, in order to insure ourselves of proper measurements with dial indicators, we have found it necessary to standardize on one particular type, not necessarily because it is better than any other, but because the errors in the dial itself, and the measuring pressure, that is, the spring tension, are known to us and due allowance is made for them. It is our practice to use a diamond point lapped to a spherical surface of a 5-mm radius in order always to insure a minimum variation in reading due to variations in measuring points.

We use fixed gages in final inspection. Fixed gages have the advantages, first, that they are set to proper tolerances in the gage room by a mechanic who is more skillful than the machine operator would be and who has the advantage of using master gages and blocks for set up. Consequently, we are assured of greater accuracy. We have, with the use of a fixed gage, an entirely different method of checking the workpiece and, consequently, the errors which may not be detected from the dial indicator are determinable by the fixed gages.

We have found, therefore, that a combination of dial indicators in the shop and fixed gages for final inspection gives us a double check-up, and is better than using either one or the other alone.

How may we improve the accuracy of our fixed gages?

I am convinced that there must be a difference in the method of measuring the "go" and "no-go" dimensions, whether it be for a bore or whether it be for a shaft. When we drive a spike, we use a sledge; for pulling it out we must use another type of tool. Similarly, when we measure "go" dimensions we must use one principle, but for the "no-go" dimension an entirely different principle. Earlier in this paper, I discussed briefly the importance of determining the following characteristics:

For holes

1 The diameter of the inscribed circle
2 The greatest existing diameter.

For the shaft

1 The diameter of the circumscribed circle
2 The smallest existing diameter.

It is impossible, due to *makro* errors, to measure a diametrical dimension with an ordinary plug gage, and yet, I think I am safe in saying that in this country, as well as most other countries, plug gages are generally used for both the "go" and "no-go" limits. In Germany, due to the recommendation of the International Standards Association Committee, it has been

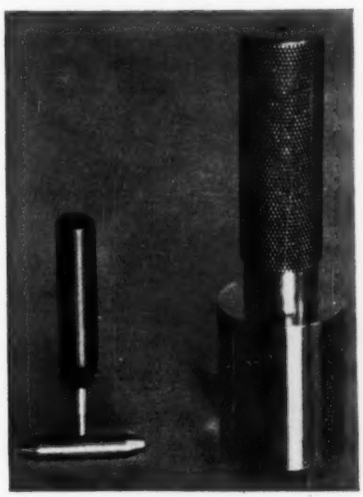


FIG. 7 "GO" PLUG GAGE AND "NO-GO" PIN GAGE FOR CORRECT PRINCIPLE OF MEASURING BORES

decided to discontinue the use of the "no-go" plug gages. In our own factory, we have not used "no-go" plug gages for the past nine years.

"GO" AND "NO GO" GAGES

In principle the "go" side, that is the diameter of the inscribed circle, should be measured by plug gages and the "no-go" dimensions by pin gages. See Fig. 7. Such a principle gives us the results we must have in order accurately to limit the *makro* errors. There must, however, be some variations in the measuring equipment, depending upon the size of the hole. For very small holes a plug gage should be used for the "go" and a flat gage for the "no-go" side. Obviously, this modification is necessary, since a pin gage of very small dimensions cannot be readily handled. If we use a flat gage, we are at

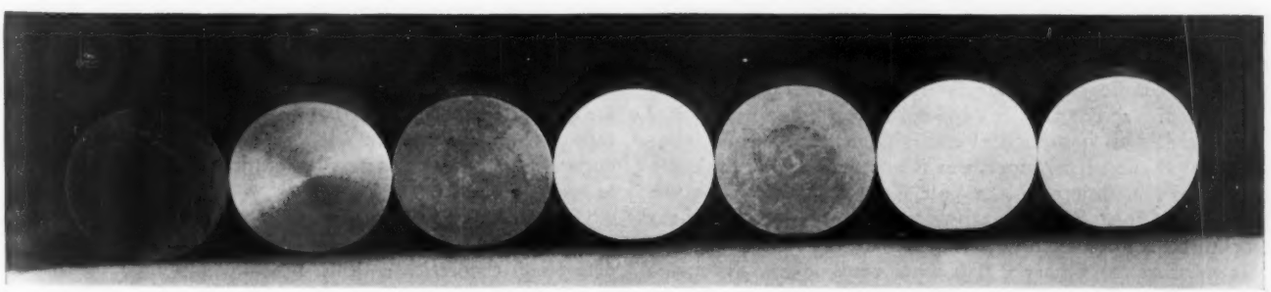


FIG. 6 STEEL DISKS HAVING DIFFERENT QUALITIES OF SURFACE

least approaching the requirements which we have laid down for the correct measurement check for the "no-go" limit, and in small holes it proves very satisfactory in practice.

GAGES FOR HOLES OF MEDIUM SIZE

For medium sizes of holes there is no difficulty in using the ideal system of a plug for the "go" and a pin gage for the "no-go." There is one possible disadvantage that must be taken into consideration and that is the fact that, where rings of relatively thin sections are involved, it is possible with a pin gage, when not carefully handled, to make the rings elliptical with only a slight pressure and thus obtain an incorrect result.

With this thought in mind and a desire to combine, if possible, the advantages of the plug gage as well as the pin gage in one unit, we have developed for our own use, the Te-Bo gage, Fig. 8. The body of this gage is spherical externally and is so made that the diameter of the sphere is the same as the minimum dimension required. Naturally, then, if the diameter of the inscribed circle of the hole is larger than the minimum dimension required, the gage can be introduced into the hole. On the spherical surface near the outer face there is a spherical projection. The distance from the surface of the projection to the diametrically opposite surface of the gaging body is equal to the maximum dimension. The difference between the maximum and minimum dimensions, that is the tolerance, is consequently represented by the height of the projection above the surrounding spherical surface. When the minimum condition is checked, the gage is introduced into the hole with the handle tilted slightly upward. This gives us our "go" reading. For the "no-go" reading the handle is tilted downward, and, if the movement is impeded, the hole is approved. If the tilting movement is not impeded by the interference of the projection, the hole is too large. By the performance of this simple operation in different positions of the workpiece, the hole is checked throughout.

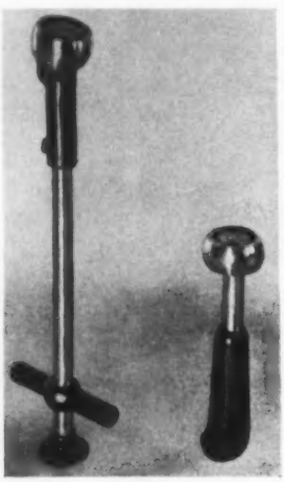


FIG. 8 TE-BO GAGES

FIG. 9 (RIGHT) PIPE GAGE OF BUILT-UP CONSTRUCTION FOR "NO-GO" DIMENSION

It is, of course, observed that when the "no-go" dimension is to be checked, the diameter of the body itself prevents the hole from assuming an elliptical shape. Thus, we have combined a simple method of checking the diameter of the inscribed circle and the largest possible diameter in one simple gage, which will insure accuracies undeterminable when "go" and "no-go" plug gages are used. With the gage correctly handled, one is always certain of obtaining the same measuring pressure, i.e., the weight of the gage for the "go" dimension and the weight of the handle for the "no-go" dimension. A modification of the gage for long holes can be made whereby the body can be tilted by means of a special handle with spring action.

GAGES FOR LARGE HOLES

When we come to larger holes, gages following the principle of the inscribed circle become too unwieldy and some modifications must therefore be made. Today, the pin gage is generally used for both the "go" and "no-go" limits. These pin gages are always made with very small measuring surfaces. The difficulty of proper measurement with these gages is known to all of us. Furthermore, for the "go" side, only a small part of the hole can be checked, which offers no assurance as to the size of the inscribed circle. There should be no difficulty in improving the accuracy of measurements if the pin gage employs a built-up construction with the ends of pins having mushroom heads. Such a gage is shown in Fig. 9. For the "go" side the ends have large heads in order to check as large an area of the inscribed circle at one time as possible. For the "no-go" limit, it is desirable to have one end large, Fig. 9. and the other small. The large end enables one to center the gage, providing the contact angle is at least 4 deg. At the other end, a small head is used which enables us to obtain a check for the diametric dimensions.

With equipment of this type, which, as will be observed, takes into consideration only the basic principles of the measurement of the diameter of the inscribed circle and the maximum existing diameter, we shall have gained a better knowledge of what we are doing, and as a result will have improved substantially our manufacturing methods and our products.

For the measurement of the shaft, the principles already laid down require consideration of (1) the diameter of the circumscribed circle, and (2) the minimum existing diameter.

Theoretically, we should, therefore, have a ring gage, the bore of which is made to the maximum limit and the length of which is equal to the length of the surface to be measured. Generally speaking, however, it would be impracticable to use a ring gage and particularly one having a length equal to the length of the measured surface. However, we can, in the design of a snap gage, make the measuring surface of this gage relatively long, and so at least simulate to a degree the theoretical necessity for measuring as great a length as possible.

FIG. 10 SNAP GAGE OF NEW DESIGN

("Go" side with line-to-surface contact; "no-go" side with point-to-surface contact.)

For the "no-go" dimension we should have a gage with two points set to the minimum limit, for only by two points can we determine theoretically the absolute minimum diameters. But this is also impracticable, for with two points, it is difficult to locate a real diameter.

A NEW SNAP GAGE

Fig. 10 shows a snap gage of a new type which takes the foregoing problems into consideration. On one side is a flat surface, which can be regarded as the measuring table for both "go" and "no-go." On the other side, the "go" is made as a projection, consisting of a part of a cylinder which runs the entire width of the gage. For the "no-go" one or two spherical knobs are provided, which will then measure the smallest diameters on the work piece.

EFFECT OF PRESSURE IN USING GAGES

There is still a further consideration, and that is, What measuring pressures shall we use? In this country I, believe, snap gages are generally of very much heavier section than the gages used in most other countries, and so the springing of the measuring surfaces is limited. However, even with this rigidity, it is quite possible to obtain a spread of the jaws which may be from 0.0001 in. to 0.0002 in. or more. I do not know that there is any settled practice, but it might be concluded from the snap gages I have purchased and examined, that they are so set that the dimensions prescribed are maintained only at no load. When we remember that the normal forces which tend to spread the gage are from four to six times greater than the tangential measuring load, it is easily understandable why this spread of the measuring surfaces exists and why limit dimensions under load must be considered.

It is probably also a fact that surfaces are adjusted parallel at no load. When any spread takes place, these surfaces are no longer parallel, and not only has the effort and expense necessary to produce parallel surfaces been lost, but, obviously, the accuracy of the gages themselves. To correct this condition, I have proposed using for the "go" side a combination of line and surface contacts which will always be parallel, no matter what the spread may be, and for the "no-go" side a combination of point to surface.

It may be assumed that the practice has been no more uniform in this country than in other countries; in some cases a measuring pressure equal to the weight of the gage will have to be established; in others, some pressure either definitely prescribed or incidental.

How are we to determine accurately what this shall be? Certainly it seems desirable to have a standard in order to set the gages under the necessary measuring pressure. An instrument for carrying out this measurement effectively is shown in Fig. 11. It consists essentially of a balance with the gage itself on one arm, counterbalanced by a variable weight on the other. A reference disk is now placed in position and the gage may be checked so that it just passes the disk when the prescribed load is added.

In our own plant, because of the relatively thin sections of the products which we make, we have found it necessary to use as our basis a very limited measuring load of 100 g, and all of our snap gages are set under this load. In our gage room we have a number of these balances, and they are also available in the various production departments. This permits an operator from time to time to judge his measuring load and get the required feel. It is quite surprising how quickly even an inexperienced inspector will become an expert on the proper feel of the snap gage with the use of this balance. We consider such equipment invaluable in our own plant, for it has proved to be a very effective means of improving our shop practice.

These seemingly minor changes in equipment for the measurement of the bore and the shaft give us astounding results. I am quite safe in saying that were these changes made in the average plant it would immediately mean a rejection of 30 per cent of the parts which are now passed as "satisfactory" under the ordinary gage methods. The natural consequence of this is, therefore, the necessity either for the broadening of prescribed tolerances or for more accurate workmanship. This brings us inevitably to what I consider the most important point, and that is the necessity for knowledge of what we are *actually* doing.

ACCURATE GAGING TECHNIQUE IMPROVES RELATIONS BETWEEN ENGINEER AND SHOP SUPERINTENDENT

There has always been a divergence of ideas between the engineer and the shop superintendent. On the one hand, the engineer, from past experience and past trouble, is anxious to limit and reduce the tolerances without definite knowledge as to whether or not the tolerances which he has specified are actually being observed in shop practice. How, then, can he know whether or not the tolerances are satisfactory or whether an improvement is necessary? The shop superintendent, on the other hand, must consider many practical manufacturing problems, the characteristics of his equipment, and a variety of the limitations with which he may be surrounded.

A common understanding *can* be obtained by a better knowledge of exactly what is being done and what can be done in the shop but this is only possible by accurate gaging technique. Use of the new principles and methods of measuring which I have described may, in some cases, mean a change, or the broadening out, of present tolerances to enable the shop to do what the engineering department thinks is required. Such a fundamental change is not a matter of days or weeks, but will require several months or even years. Once it has been accomplished, it may be possible to use some system of designation or nomenclature which, in turn, may further assist in that for which we all strive—a thorough understanding between engineering and manufacturing in their common problems.

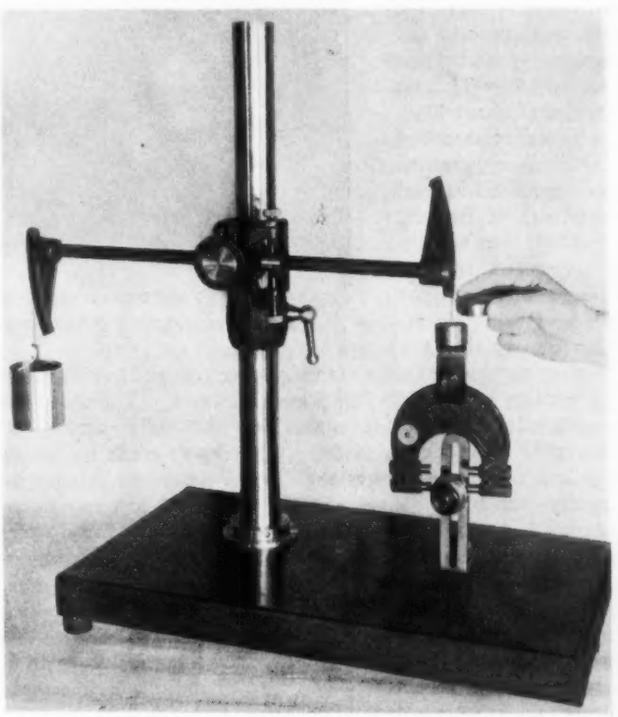


FIG. 11 SNAP-GAGE BALANCE

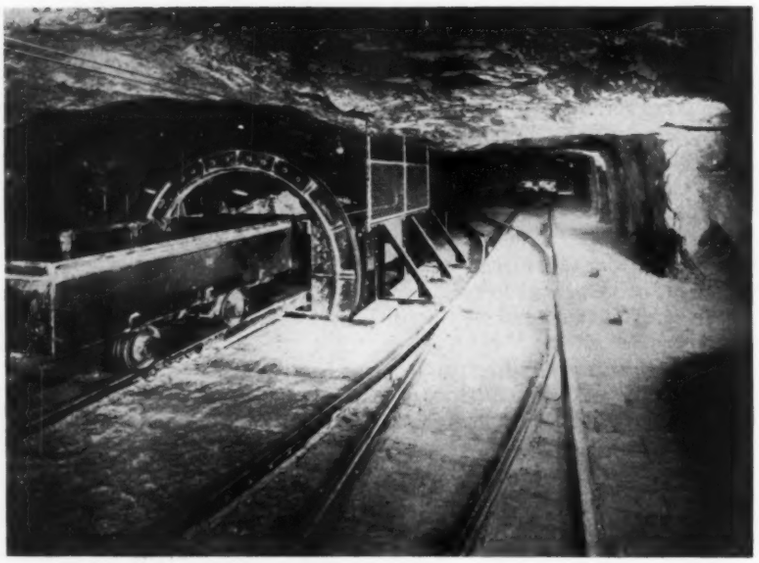
(The dimension of a snap gage depends on the measuring load.)

MECHANIZATION *of the* POTASH MINES *in* NEW MEXICO[1]

By HOWARD I. SMITH and RICHARD V. AGETON

UNITED STATES GEOLOGICAL SURVEY

THE AMERICAN potash industry, begun in 1608 by the inclusion among the colonists of men experienced in making potash from wood ashes, did not become a factor in commerce until several years later. An improvement over the old pot process for making potash was published by Thomas Stephens[2] about 1757, and the first patent of any kind to be granted was issued to Samuel Hopkins, of Boston, in 1790, for an improvement in the manufacture of pot and pearl ash. Massachusetts was then the center of technical experiment and production, and in 1788 it was reported to have nearly 250 potash factories. The wood-ash potash industry reached its peak about 1825, when the exports amounted to about $2,000,000. The export trade had many ups and downs until after the Civil War, when it dropped rapidly from an annual value of about $750,000 to a very minor amount. At the turn of the century, however, wood ashes were still used domestically in making soap and other products. The sudden drop in exports after the Civil War was due in great measure to the establishment of better transportation, which permitted commerce in more bulky farm products of less value per ton, such as lumber, and in products that yielded greater returns for the labor involved, such as grain and livestock. Other factors were a drop of nearly 90 per cent in the price of soda ash from 1810 to 1860, due to the development of the Le Blanc soda-ash process, and the substitution of sodium salts for potash in the manufacture of soap and other products. Other factors slowly felt were the discovery of mineral potash near Stassfurt in Germany in 1843 in the course of boring for rock salt, the recognition by von Liebig about the same time of the importance to plants of potash in the soil, and the discovery of carnallite in sinking a shaft for salt in 1856. The initial German production was 2293 tons in 1861, but very little German potash entered America until after the Civil and Franco-Prussian wars. So far as known, the first use of German potash in an American agricultural experiment station[3] was in 1872 at the experimental farm of the Pennsylvania State College. The exports from Germany of potash for industrial purposes exceeded those of potash for use in agriculture until 1879, and in Germany itself more potash was used in industry than in agriculture until 1890.



ROTARY DUMP AT BOTTOM OF MINE SHAFT, POTASH COMPANY OF AMERICA, WHERE SALT IS DUMPED INTO ORE POCKET TO BE CRUSHED BEFORE HOISTING

The use of mineral potash in agriculture was limited for many years. Its extended use after it became commercially available resulted from a market created throughout the world by educational work undertaken in the efforts to sell the products of the German mines, which were developed for a capacity greatly in excess of the available industrial markets.

The name "potash" came into use from the iron pots used to evaporate solutions leached from plant ashes. The potash thus produced was mostly an impure potassium carbonate, but the word was used later to include caustic potash obtained by treating the crude potassium carbonate with lime. It is still used as a general term for various compounds of potassium, but the term "pure potash" is applied to the theoretical equivalent in K_2O, a compound which is never found in nature nor manufactured in commerce.

By 1910 the commercial interest in domestic potash production had become dormant, and it so remained until 1915, when the German government forced the cancellation of contracts that had been made in good faith in 1909. The cancellation of these contracts resulted in an estimated loss to American purchasers of about $28,000,000. This action aroused a determination in Congress to find an independent supply of potash, and the task of finding it was assigned to the United States Geological Survey and the United States Department of Agriculture. In the next few years the various possibilities for the production of potash were investigated and described in published reports, and in 1915, the year in which imports from Germany

[1] Published by permission of the Director, U. S. Geological Survey.

[2] "The Method and Plain Process for Making Potash Equal if Not Superior to the Best Foreign Potash," by Thomas Stephens, London, printed at the Dunciad in Pater Noster Row.

Contributed by the Process Industries Division and presented at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[3] Pennsylvania State College Annual Report, 1873.

were cut off, the modest quantity of 1090 tons of pure potash was produced in this country. The output had increased to a record of about 200,000 tons in 1935.

During the war $50,000,000 was invested in the production of American potash from many sources, of which the shallow lakes of western Nebraska were the most productive during the war period. With the end of the war and a 90 per cent drop in price, nearly all of the 128 plants in operation in America ceased production. Three of these plants continued to operate, one producing from California brines, one from cement dust, and one from distillery waste. Two new sources of potash were recently developed in the Permian basin in New Mexico, one in 1931 and the other in 1934. This paper is confined to the prospecting and development of this new source of potash.

DISCOVERY

The discovery of potash in the Permian basin of Texas and New Mexico was a progressive one. In 1910 the United States Geological Survey called attention to the red beds of these states as being worthy of notice as possible sources of potash salts. In 1912 J. A. Udden, director of the Texas Bureau of Economic Geology, found potash in the brine of a well drilled for oil in Dickens County, Texas. He later picked out mineral salts that showed on analysis notable percentages of potash, but not until 1921, when R. K. Bailey of the Geological Survey identified polyhalite, were any of the minerals definitely known. In 1925 sylvite was independently identified by Bailey and W. D. Turner in samples of cuttings furnished by V. H. McNutt from the McNutt well, drilled for oil and gas by the Snowden-McSweeney Co. in Eddy County, N. Mex. The discovery of sylvite led to core drilling by this company and eventually to the development of the field by the United States Potash Co., organized by the Snowden-McSweeney Co.

Early core drilling was very unsatisfactory on account of the high loss in drilling the brittle and soluble salts. The recovery in the No. 1 McNutt core test was about 80 per cent, a great improvement over previous experience in such drilling. This comparatively high recovery of core was due mainly to the use of the modified, nonrotating, inner-tube type of double-tube core barrel[4] designed and perfected by Messrs. Whitehead and Ruellan, who were in charge of drilling operations for the company. All but one of the core tests in this basin have been drilled by the Sullivan Machinery Co. and the Pennsylvania Drilling Co. Contract prices per foot have ranged from $17 in 1926 to $4 in 1934. This variation has been due in part to the depression and such other factors as roads, water, moving distance, number of holes under contract at one time, and improvement in drilling procedure.

One test was drilled by David Muncey, of Amarillo, Texas, with a rotary well rig, compressed air being used to blow out the cuttings. This method might be used to advantage in formations of certain types, particularly those tending to swell in the presence of water.

Both gasoline and steam have been used for power. Normally, the beds to the top of the salt are churn-drilled, and the salt is core-drilled. The specifications require a $2^1/_2$-in. core at the bottom of the hole. The speed of drilling has been increased from a daily average of 18.7 ft for the first 20,000 ft drilled to 40.1 ft for the last 10,000 ft. The amount of coring in the holes has ranged from 100 to 1676 ft.

The drilling solution has been progressively improved, first by using a salt-brine solution, then a salt-magnesium solution, and finally a salt-potash-magnesium solution heated to bottom-hole temperature, with the result that cores now obtained are either not at all or only slightly etched by the solution.

DEVELOPMENT

The sinking of the first shaft in this field, near Carlsbad, N. Mex., was begun by the United States Potash Co. in December, 1929, and completed in January, 1931. Shaft sinking here is not easy, owing to the character of the overburden, which is composed of alternate layers of clay, shale, quicksand, limestone, and anhydrite and which has been proved to contain six potential water-bearing strata.

In sinking, jackhammers with straight cruciform bits and the usual V-type cut of shaft round were tried originally. However, it was found that in many of the strata, particularly in clays and sands, the shots would chamber and not break clean. This difficulty was overcome by the use of jackhammers with nonrotating chisel bits similar to those employed in breaking up pavements. These bits were entirely satisfactory in soft formations and eliminated the necessity of blasting. The same practice has been used in sinking the air shaft of this company and in sinking the shafts for the Potash Co. of America, regular rounds and blasting being used only in the sandstones, limestones, anhydrites, and salt. In the salt section of the Potash Co. of America, 52 holes were used in each round as against 32 holes used in the limestones and anhydrites.

The Potash Co. of America constructed three sumps in its main shaft. To handle the water it installed two centrifugal pumps with a total capacity of 500 gpm and one triplex pump with a capacity of 200 gpm. The triplex pump raised the water from the 400-ft level to the main pump station on the 200-ft level, which has a storage capacity of 200,000 gal. Plans call for the installation of a Byron-Jackson deep-well pump to handle the present flow of 135 gpm.

PRODUCTION

When the United States Potash Co. opened its mine all drilling was done by compressed-air machines using different makes. Blasting was by the cap-and-fuse method. All ore was shoveled into the cars by hand and hand-trammed to the shaft pocket, where it was dumped into cans and hoisted to the surface. Now, however, modern machinery, electrically operated, is used throughout in both mines. The potash seam is undercut on the bottom of the bed with Sullivan machines. The potash salts are then drilled with electric auger drills and all blasting is accomplished by electrical detonators,[5] using recommended safety practices. Misfires are few indeed.

The undercutters used in the United States Potash Co.'s mine have an 8-ft cutter bar, and those at the mine of the Potash Co. of America have a $7^1/_2$-ft cutter bar. The cutting bits are pointed with stellite or other alloy, but other types have been tried. These bits have proved entirely satisfactory, being good for about 80 to 100 linear feet.

The product is mechanically loaded after shooting. The United States Potash Co. uses a three-drum Sullivan scraper slide with a box-type scraper and a Goodman hydraulic shovel of the caterpillar type. Both of these machines can be used either in rooms or in narrow entries and connections between entries, but they require a minimum headroom of about 8 ft. This requirement has not caused trouble, as the bed being worked is from 8 to 12 ft thick, but should the bed thin out toward the outer limits of the deposit loading practices will have to be revised.

At the mine of the Potash Co. of America a Sullivan scraper

[4] "Special Features of Core Drilling in the Salt Beds of Western Texas and New Mexico," by J. S. North, U. S. Bureau of Mines Information Circular No. 6156, August, 1929.

[5] "Drilling and Blasting Practice of the United States Potash Co., Carlsbad, N. Mex.," by C. A. Pierce, A.I.M.E. Tech. Pub. 672, February, 1936.

loader is also used. This loader, however, is designed to operate with a 6-ft headroom and loads from the side rather than from the end. The scraper in use at present is designed for side loading in rooms 60 ft wide and 200 ft long. A Jeffrey face loader is used at this mine for all narrow work. This has an 11-ft loading boom and requires only $4\frac{1}{2}$ to 5 ft of clearance. The seam here worked is from 4 to 7 ft in height.

Both storage-battery locomotives and trolley locomotives are used in the United States Potash Co.'s mine, but only storage-battery locomotives are used in the mine of the Potash Co. of America.

One 150-ton skip pocket has been constructed by the United States Potash Co. and two by the Potash Co. of America—one for sylvite ore, with a capacity of 150 tons, and one for waste salt, with a capacity of 75 tons.

The United States Potash Co.'s mine is equipped with 3-ton side-dump Granby cars having a 24-in. track gage. The cars are dumped over a Granby side dump on to an inclined grizzly above the skip pocket. The crude potash salt goes from the skip pocket into 4.6-ton underslung skips and is hoisted to the surface.

At the mine of the Potash Co. of America the crude potash salt is loaded into $4\frac{1}{2}$- to 5-ton steel cars having a 42-in. track gage and dumped over a Card rotary dump into a hopper. From this hopper the salts travel over an apron pan feeder, 42 in. wide, to a Jeffrey single-roll inserted-tooth crusher set to crush to a maximum of 3 in., and thence to the skip pockets from which it is loaded into 5-ton underslung skips.

At both mines the loading of the skips is semiautomatic. At one the weight is the controlling factor; at the other, when the ore fills the skip it operates a trip that shuts off the flow.

At the United States Potash Co.'s No. 1 shaft a double cylindrical-drum Nordberg hoist, driven by a slip-ring induction motor rated at 350 hp, is used to hoist the salts from the mine to the surface storage bin. The hoist has a capacity of 150 tons an hour at a hoisting speed of 1000 fpm. The headframe is 110 ft high and contains one bin having a capacity of 250 tons. The shaft is 1062 ft deep.

The Potash Co. of America also uses a double cylindrical-drum Nordberg hoist. It is driven by a 400-hp direct-connected motor and has a rated capacity of about 200 tons an hour and a rope speed of 1200 fpm. This hoist is also equipped with a 22-ton flywheel on the motor generator to aid in decreasing starting torque on the motor. Both hoists are equipped with electric speed and overwind controls. The headframe of the Potash Co. of America is 125 ft high and contains two bins, a 350-ton bin for the potash and a 100-ton bin for the waste salt. The shaft is about 1100 ft deep.

Both mines are equipped with complete machine shops and electric shops on the surface, as well as change houses and office buildings. Only the crushing plant of the United States Potash Co. is at the mine location, but both crushing plant and refinery of the Potash Co. of America are at its mine. Small machine shops and electric shops are also maintained underground in both mines. Electric lighting is used throughout both mines, and all men are equipped with approved Edison storage-battery cap lamps.

Ventilation is important in these mines, both for the removal of vitiated air due to blasting and ordinary mine operations and also in view of the possible occurrence of gas. There have been only a few occurrences of gas in the potash bed being mined, and none of these contained a dangerous percentage of methane (CH_4), the highest being 0.3 per cent. Reversible fans have been installed at both mines. The United States Potash Co. has a 4 × 6-ft Robinson reversible mine fan with backward curving blade, having a capacity of about 85,000 cfm. This fan is housed in a steel-and-concrete building and is so arranged that the air current can be reversed quickly and easily should necessity arise. At the present time the main hoisting shaft is downcast, and the No. 2 or fan shaft upcast. Ground temperatures in the salt seldom exceed 74 F, and air temperatures are rarely over 79 F, even on return air and in dead ends.

At the mine of the Potash Co. of America only the No. 1 or hoisting shaft has reached the potash bed being mined. At this mine two Jeffrey air-vane straight-flow fans, operating in tandem, are used. This system gives a flow of 40,000 cfm, which has been ample up to the present time. Concrete overcasts and undercasts are used in both mines to control ventilation.

At the No. 2 shaft of the Potash Co. of America construction has been completed and a 7 × $3\frac{1}{2}$ ft reversible Jeffrey fan, having a capacity of 150,000 cfm, has been installed in a steel and concrete housing at the collar of the shaft. At present this fan is used only in shaft sinking, but the company plans to operate it for exhausting after the shaft has reached the potash bed.

Railroad track scales are installed at both mines to weigh all shipments. At the mine of the Potash Co. of America, both manure salts and muriate are shipped directly from the crushing plant and refinery over a branch line of the Atchison, Topeka & Santa Fe Railway to the main line at Carlsbad. The United States Potash Co. transports the crushed crude salts over a company-owned tramroad to its refinery east of Loving, from which both manure salts and muriate are shipped over a branch line of the Atchison, Topeka & Santa Fe Railway to the main line at Loving. The crude salts consist of sylvite (KCl) and halite (NaCl), referred to as salts, with small amounts of other minerals and clay.

REFINING METHODS

The mechanical treatment of the crude salts as mined is similar in both plants, except that the Potash Co. of America does primary crushing underground. The mine-run material is taken from the headframe bins by belt conveyors to crushing-plant bins and thence over crushers and screens of various types to make a 6- to 10-mesh product, sold to the trade as manure salts and containing from 40 to 48 per cent of KCl equivalent to 25 to 30 per cent of K_2O. Neither hand-picking nor sorting is done in either plant, and the foregoing grades approximate the run-of-mine product.

At the United States Potash Co.'s refinery plant the crude crushed salts are converted by a process of solution and fractional crystallization in a single refining step to make a finished product averaging more than 99 per cent muriate of potash (KCl). The process is based on the relative solubilities of sodium chloride and potassium chloride. When both salts are present in quantities to allow complete saturation they are radically different in their response to changes in temperature. Increase in temperature enhances the capacity of mother liquors for potassium chloride but effects little change in their capacity for sodium chloride. A selective extraction of potassium chloride is thus made possible.

The process includes extraction, cooling, filtering, and drying. Heat is introduced into the system by means of heat exchangers, fed with cold mother liquors. The process is cyclical in nature and may be described as largely continuous.

In producing the high-grade muriate the crude salts designated for treatment are dumped into a hopper nearer the plant. Thence the salts are fed on to an inclined belt conveyor, which carries them to a surge bin in the plant. From this bin they pass over Traylor vibrating feeders to an elevator that discharges

into measuring bins, from which they go to a battery of dissolvers or extractors.

The dissolvers when charged are closed, and preheated mother liquor near the boiling point is added to the salts to leach out the potassium chloride. This mother liquor, which has been previously saturated with sylvite and halite at room temperature, and then heated nearly to the boiling point, has an increased potential capacity for sylvite of approximately one pound of sylvite per gallon of mother liquor. This causes a selective action, dissolving the sylvite (KCl) and leaving the salt (NaCl) behind. The residual salt is flushed from the dissolvers with cold water. The dissolvers are then recharged as previously outlined and the cycle is repeated.

The saturated liquor from the dissolvers is pumped continuously to three vacuum coolers in series. In these vessels constant boiling is maintained in three steps at progressively reduced temperatures. Steam from the liquor is condensed in tube condensers and the residual gases are removed by ejectors. In this manner the saturated liquors from the dissolvers are finally reduced to approximately atmospheric or room temperature and then charged with crystals of potassium chloride (muriate) in suspension. The potassium chloride, which is taken up from the crude salts in the dissolvers, is thus precipitated in the vacuum-cooler process.

This charged liquor, with the crystals still in suspension, is fed on to a top-feed Oliver filter. Here the muriate crystals are recovered and the cooled mother liquor returns to the head of the plant, where it is again heated and charged into the dissolvers. The muriate crystals are then dried and screened and ready for shipment either in bulk or in bags as the order requires.

The refinery of the United States Potash Co. was placed in operation in September, 1932, and the capacity was doubled in 1934. The scheme of fractional crystallization to purify crude salts containing sylvite is not new, but improvements in apparatus, made available by pioneering American manufacturers of such equipment, have allowed advantage to be taken of the latest technical advances as they occurred. Such a process naturally makes use of centrifugal pumps, storage tanks, and screw and belt conveyors designed to meet the corrosion problems characteristic of all works handling salt. Alloys of various kinds, concrete, and wood are used in appropriate places.

The refined potassium chloride is clear white and has the physical appearance of table salt. This is the first refinery for the handling of soluble crude-potash salts constructed in the United States. At present it has a capacity of about 400 tons of muriate or refined potassium chloride a day.

The power is generated by steam, turbogenerators of the Curtis type being used. Steam, used for both power and heating, is generated in Stirling boilers by the use of natural gas from eastern New Mexico. Full use is made of exhaust steam from the turbines for heating. All condensates are returned to the boilers, to insure a suitable boiler feedwater. Electrical energy is generated at 440 volts and is stepped up to 33,000 volts for transmission to the mine, about 13 miles to the north.

At the plant of the Potash Co. of America the crude salts are concentrated by flotation. The separation by flotation of sylvite and halite, which differ only 0.16 in specific gravity, can be accomplished in the laboratory in many different ways. Initial experimental work on mechanical separation of halite and sylvite by the United States Bureau of Mines led to a cooperative agreement with the Potash Co. of America, at the Missouri School of Mines, where small-scale tabling tests were made to produce a coarse ground product, which was considered desirable at that time. While these tests were favorable, it was decided to make further experiments before attempting production on a commercial scale.

Later research by the company's staff, under the direction of Dr. A. J. Weinig, of the Colorado School of Mines, and L. D. Anderson, of Salt Lake City, Utah, resulted in the development of the flotation process now in use at the company's plant. The adaptation of flotation to the salines is one of the outstanding developments in milling operations during the last decade. All concerned are to be congratulated both on the preliminary experimental work and on bringing the plant to the productive stage.

In producing the refined product the crude salts from the crushing plant are transported over belt conveyors to two bins at the head of the concentration plant or refinery. The mill feed from the two storage bins goes into two Pebble ball mills, to which is added brine saturated with sylvite and halite at room temperature. This is done in order to preclude solution of sylvite during grinding. The finely ground product from these mills goes into two Akins classifiers in closed circuit with the Pebble mills, the fines from the classifiers passing on to a Dorr thickener.

From the thickener the pulp goes to a Minerals Separation Co. 12-cell rougher flotation machine, at which certain reagents are added. At present the salt (halite) is floated and the sylvite depressed, but, should it be desirable, this process can easily be reversed.

The float or salt from the rougher is joined by the salt from the cleaner for further treatment to extract the residual sylvite. The salt tailings as discharged contain only a minimum of sylvite.

The middlings from the first flotation machine or rougher go to a 6-cell cleaner for further treatment. The middlings from the cleaner are reground and retreated, and the salt tailings from it join with the rougher salt as just mentioned.

The muriate (concentrated sylvite) from both machines is taken to three Fletcher centrifuges, and the pulp from them to a Ruggles-Cole drier. The dried muriate goes over a water-cooled drag conveyor to the muriate warehouse, for shipment or storage as the need requires.

This refined muriate, while retaining the distinctive pink color of the crude potash salts of this district, contains from 96 to over 99 per cent KCl or the equivalent of more than 60 per cent K_2O.

The first unit of the plant, as designed and operated, has a daily output capacity of about 200 tons. A second unit is contemplated as soon as conditions warrant.

At this mine all power is developed by three Diesel engines with a total of 1800 hp. In addition there are three air compressors, two Diesel-driven and one motor-driven. The soft water for use in the jackets is shipped to the mine in railroad cars, but the company expects to put in a water-softening plant shortly.

At both refineries all products are mechanically loaded into railroad cars, and these plants are now prepared to supply the trade with any grade or product desired, from manure salts with the equivalent of 25 per cent of K_2O to muriate of a purity acceptable to the chemical trade.

Very little water is used in the process at the mine of the Potash Co. of America, that pumped from the shafts being sufficient, as the salts are not put into solution. An interesting development has been the use of the jacket water from the Diesel power plant to heat the brine developed in the process, this procedure having a desired cooling effect upon the jacket water, as well as affording a heat transfer. At the United States Potash Co.'s plant water for the refinery is obtained from the Pecos River, some of it is softened for refinery use.

PREVENTION OF ACCIDENTS

Both of the companies operating in this field have received awards from the Joseph A. Holmes Safety Association, sponsored by the United States Bureau of Mines, for notable work in the prevention of accidents. One award was made to the Potash Co. of America for the sinking of a 1000-ft shaft without a single lost-time accident, and one to the United States Potash Co. for successful operation of the mine through one year without a lost-time accident. The latter company has been nominated for an additional award of the same nature. These enviable records have been accomplished through the careful and conscientious work of all officials and employees. Regular courses in accident prevention, first-aid training, and mine-rescue training have been given by the United States Bureau of Mines ever since the mines were first operated, and at the present time about 90 per cent of the men employed in the industry have received this training.

The careful safeguarding of all mechanical and electrical equipment, with inspection of hoist cages, skips, and other mechanical equipment, is an all-day, every-day affair. There have been no accidents due to the mishandling of either powder or detonators. At both mines modern powder houses are used for storage of powder on the surface, and only sufficient powder and detonators are taken underground for one shift's blasting, which is done on the night shift.

GENERAL INFORMATION

From the beginning of production of potash in New Mexico in 1931 to December 31, 1935, more than 1,250,000 tons of crude potash has been mined and shipped as muriate or manure salts in 12,924 railroad cars. The rate of production in 1935 averaged about 1500 tons daily, but the two mines are capable of hoisting 350 tons an hour. The two New Mexico refineries have a rated daily capacity in excess of 600 tons of muriate, and plans have been completed to increase this to 800 tons.

Of the crude potash salts produced from the two New Mexico mines during 1935, 98 per cent were mechanically handled, from the time they were drilled, undercut, and blasted until they were placed in the railroad cars for shipment.

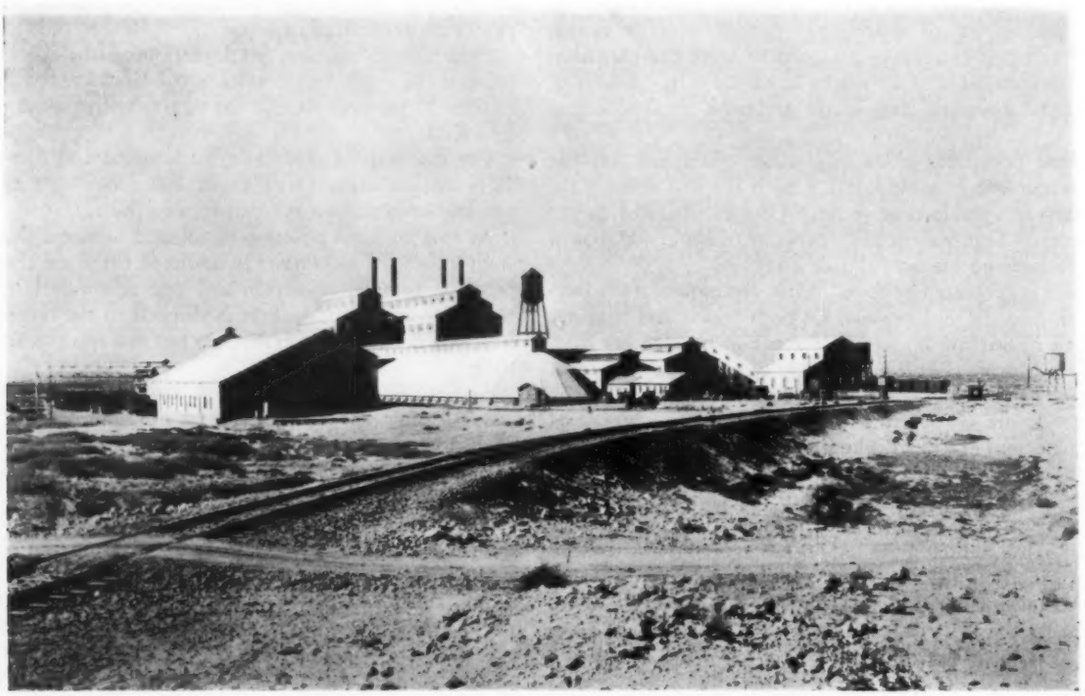
The potash industry in New Mexico employs an average of 625 men, and about 50 additional men are employed on highways and other construction of major benefit to the industry; between 2500 and 3500 persons in the vicinity of Carlsbad obtain their living from this newly created potash industry conceived and brought to production during the depression, despite the low prices for potash prevalent in that period. The low prices of potash were not due entirely to the depression. Foreign interests, mainly in France and Germany, had long dominated both the international and the domestic potash situations. With new production entering this market from Spain and Russia, as well as from the United States, potash prices were drastically reduced, to the disadvantage of the New Mexico producers.

Industry in the United States can hardly hope to compete directly with the low labor costs obtained in France, Germany, Poland, Russia, Palestine, and Spain, but economical operation of our domestic production to meet prevailing low prices demanded mechanization of the newly discovered deposits.

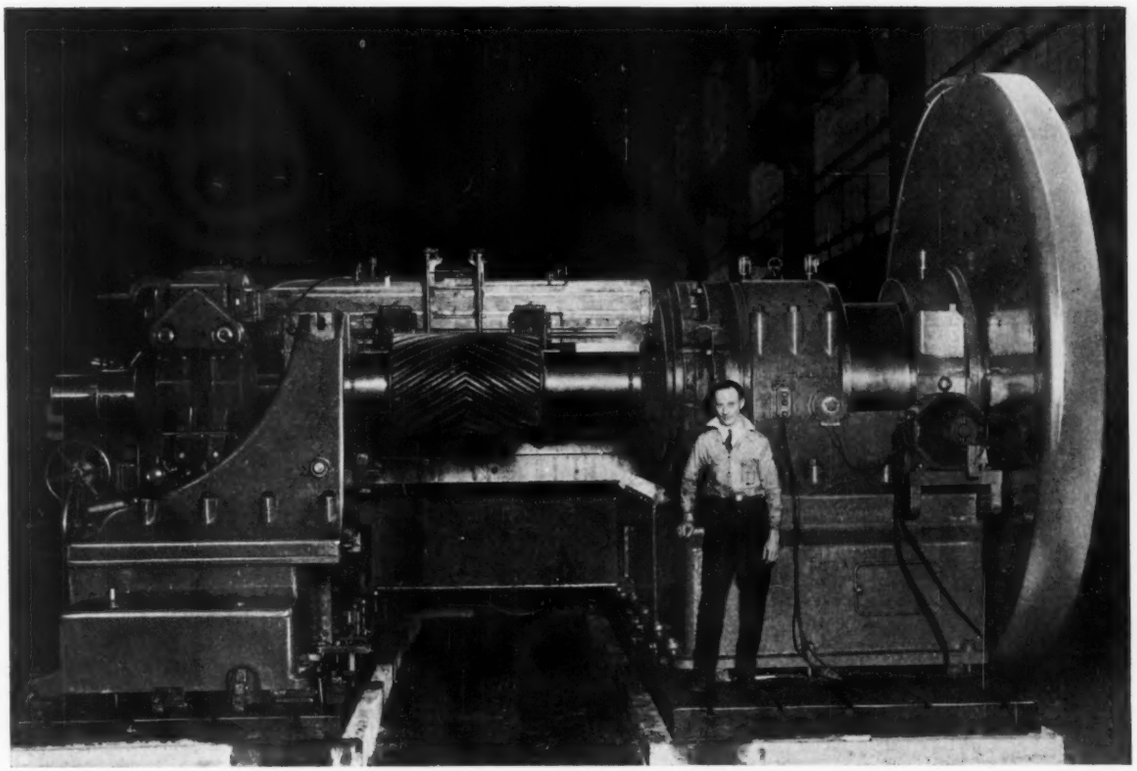
When potash was discovered in New Mexico there were no available trained men experienced in the potash industry. Crews had to be organized and trained for prospecting, development, and production. This was accomplished, and, by mechanization in so far as possible, the prevailing low prices were met by the richness of the deposits and by reducing the costs through increased production and economical operation.

ACKNOWLEDGMENTS

Acknowledgment is made of the assistance of all officials of both companies, particularly to T. M. Cramer and C. A. Pierce, of the United States Potash Co., and R. M. Magraw, R. A. Pierce, and Robert Marsh, Jr., of the Potash Co. of America, who are in charge of the properties at Carlsbad.



REFINERY OF THE UNITED STATES POTASH COMPANY



LARGE GEAR-CUTTING MACHINE CUTTING A PINION

(This machine has been specially developed to deal with heavy work and to make it more accurate than has hitherto been possible.)

GEAR NOISE— CAUSES *and* CORRECTIONS

By W. E. SYKES

FARREL-BIRMINGHAM COMPANY, INC., BUFFALO, NEW YORK

NEARLY every one engaged in the practical manufacture of gears has known of some gears which could scarcely be heard and which might, in the ordinary sense, have been termed "silent." It therefore seems safe to say that silent gears can be made. According to the author's observations, gears which run silently, in the ordinary sense of the word, can be made without great difficulty.

The causes of gear noise are (1) faulty design, (2) faulty workmanship, (3) faulty lubrication, and (4) overloads.

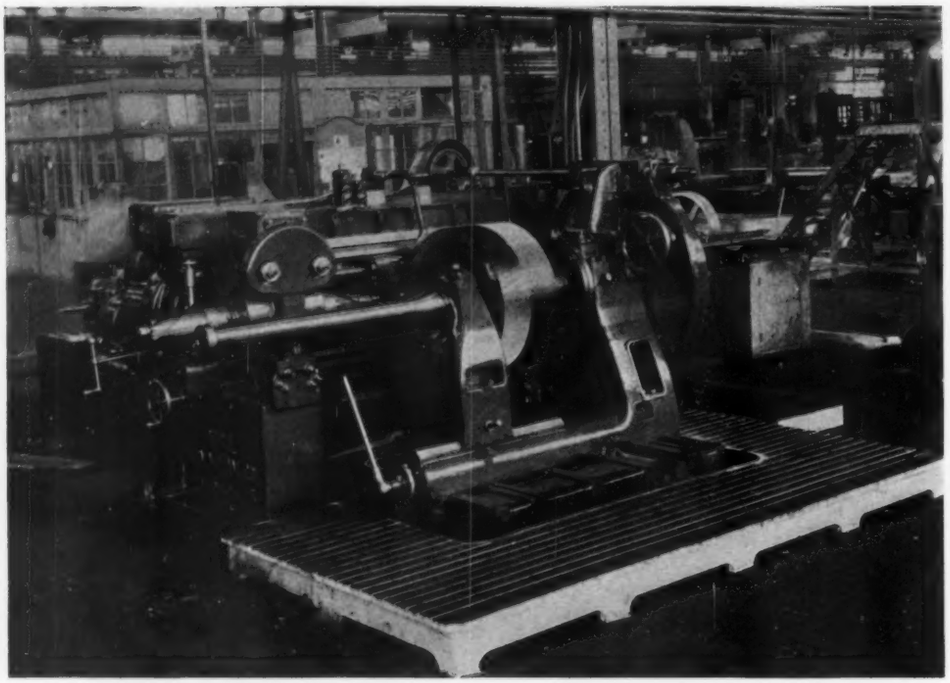
PROBLEMS OF DESIGN

The expression "faulty design" applies not only to the gears themselves but also to the design of the shafts, the bearings, and the housing. The design of the gear teeth should be in accordance with correct geometrical principles. It should be such that the gear teeth will have correct action; and in addition the helical principle should be utilized, because it is easier to obtain silent operation with gears having helical teeth than with those having straight teeth. Although the design must be correct kinematically, it is not satisfactory unless it takes into consideration the limitations of manufacture.

Occasionally, owing to ignorance on the part of the designer, straight-tooth gears are made with such a small number of teeth that the base-circle pitch is greater than the length of the line of action, and this makes silent operation impossible.

The possible faults of design are too many to enumerate. It is possible to deal with only a few of the most common faults in gear design, and it therefore seems advisable to state the requirements which have to be met rather than try to describe in detail the errors which are made.

For quiet operation it is preferable to arrange for at least two base-circle pitches along the line of contact. This necessitates a somewhat large number of teeth in the gear pair; but when there is a practical limitation of the number of teeth it is necessary to resort to modified addenda and dedenda. In general, the sum of the number of teeth in any gear pair, that is to say, the number of teeth in the pinion plus the number of the teeth in the wheel, should not be less than sixty. How-



GEAR GENERATOR SPECIALLY DESIGNED AND BUILT FOR HIGH-SPEED GEARING AND CUTTING WITH GREATEST DEGREE OF PRECISION

(This machine deals with work up to 60 in. diameter and 20 in. width of face. The gear shown is for reducing the speed of a turbine running at 6000 rpm and transmitting 1500 hp.)

ever, reasonably good results can be obtained with fewer teeth.

A reasonably rigid gear-and-pinion structure should be provided. As used in this paper the term "pinion" is intended to include worms, and the term "wheel" to include worm wheels. Pinions should have diameters large enough in proportion to their length to avoid excessive deflection, and the wheels should be so designed that they will neither deflect unduly under full load nor warp too far out of shape after being cut and heat-treated.

Shafts and bearings should be rigid. For example, the bearings should be close enough together to prevent excessive deflection of the shaft, and the bearings themselves should be sufficiently well supported to prevent excessive deflection under full load.

The design of the gear housing requires careful attention. It should be oiltight and dustproof. It should have sufficient oil capacity, and ample heat-radiating surface should be provided. If necessary, an oil cooler of correct capacity and of perfect reliability must be included in the design.

Great care must be exercised to select the most suitable type and size of bearings. In some cases antifriction bearings can be used most advantageously. In other cases the velocities are too high for such bearings and sleeve bearings must be adopted. Correct lubrication for the bearings must also be provided for.

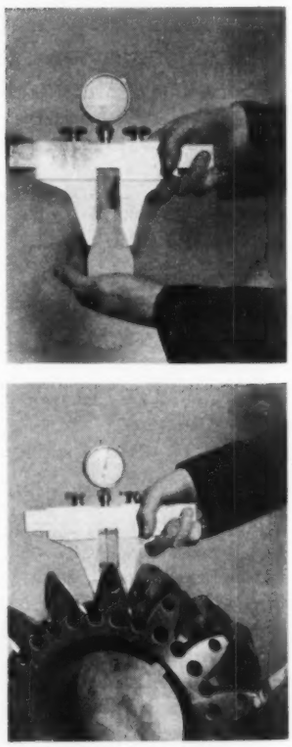
It is also desirable in the design to provide for correct gaging of the positions of the shafts, or at least not to make the design such that the gaging of the center distances or alignment or endwise adjustment, where necessary, cannot be made at all or can only be carried out with difficulty.

The selection of materials requires careful consideration. It is not sufficient merely to select materials which have the proper physical characteristics for the service required. It is advisable—even necessary—to consider whether such materials must take steps to prevent extraneous forces from pushing the gears out of position. This generally involves consideration of the type of couplings used. He also has to take into consideration the possibility that side thrusts due to overhanging loads may be imposed on the shaft projections of the gear unit. To guard against such conditions antifriction bearings are often useful, and in many cases the tapered type of roller bearing is especially valuable. In other cases deep-groove ball bearings can be used advantageously. Such bearings need very little running clearance so that any force imposed on the shafts is likely to result in very slight displacement.

Where sleeve bearings with forced lubrication must be employed because of high velocity, the use of suitable flexible couplings becomes imperative, and sometimes it is also advisable to provide a thrust bearing of the Kingsbury type.

Consideration should also be given in the design to the can be satisfactorily dealt with during the manufacturing process. For example, it would be a mistake to select a forged steel, heat-treated to such a degree before the gear-cutting operation, that it would be so hard that it would damage tools and thereby cause gear-cutting inaccuracies. It would also be wrong to choose a material to be heat-treated after the cutting operation which would be likely to warp unduly. When cast materials are used it is advisable to select one which will be reasonably uniform in hardness and cutting characteristics.

The designer's work is not properly done unless he considers and provides for the possible extraneous influences on the gear drive. He



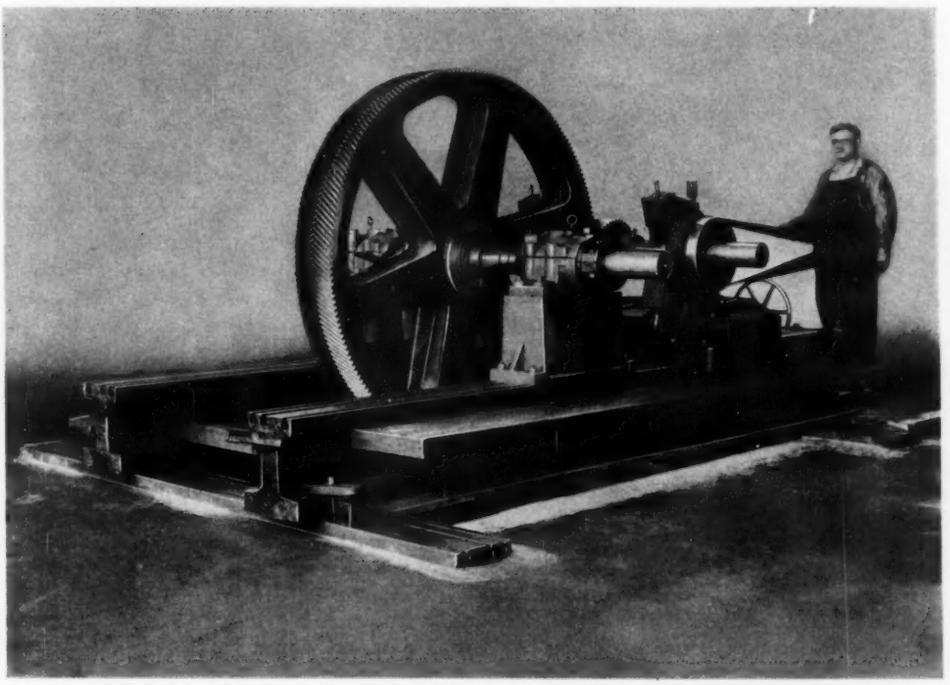
GEAR-TOOTH COMPARATOR FOR CHECKING THE THICKNESS OF TEETH

(The upper figure shows the comparator being set to the gage block. In the lower figure it is being applied to a gear-cutting tool. It compares the thickness of the tooth of the tool or a gear with that of the gage block.)

possibility of finish-cutting the gears after they are mounted on their shafts, in order to get them true relative to the journals. For this reason shafts which are too long to be accommodated in the gear-cutting machine should be avoided if possible.

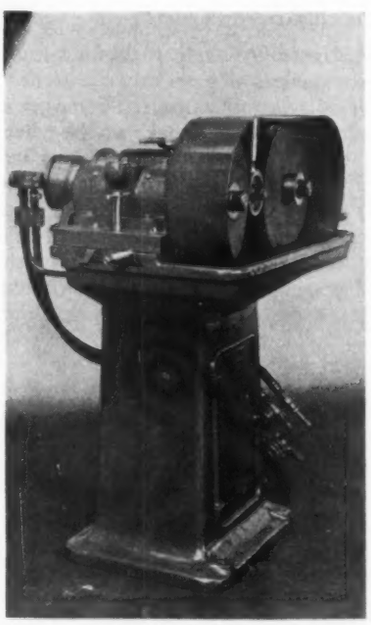
The designer should bear in mind that gears are sometimes blamed for noises which they do not create. On many occasions the author has discovered that the noise which was attributed to gears came from bearings. Therefore, the designer should make sure that the bearings themselves are not likely to become a source of noise.

In some cases oil noises are developed because the gears are immersed in too heavy a lubricant. It is the designer's duty to specify the oil level and the nature of the lubricant. In cases where the velocity of the gears exceeds a certain amount spray lubrication should be provided, and the designer must ascertain whether or not spray lubrication is required.



A LARGE GEAR BEING TESTED FOR SILENT RUNNING AND FOR TOOTH CONTACT

When a forced-lubrication device has to be embodied in the gear-unit design, care must be taken to use one which will itself not create a noise nor cause the gears to create a noise.



NEW TYPE OF LAPPING MACHINE

(The gear being lapped is in the center of two large lapping gears and the machine is so arranged that the pressure of each lapping gear on the gear being lapped is equal and opposite so that there is no tendency to displace the lapping gear. This machine is made for the rapid production of lapped gears.)

WORKMANSHIP

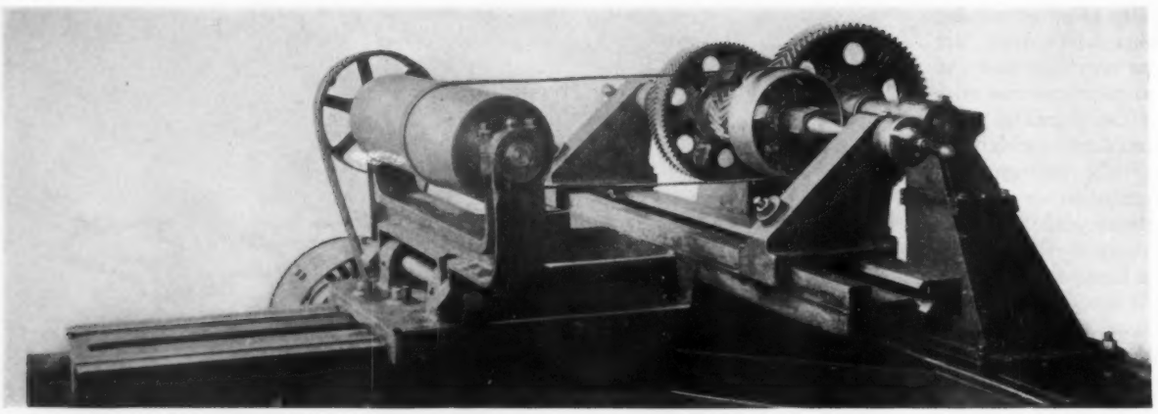
Although it is impossible to get satisfactory gear performance without correct design, it is equally impossible to obtain silent gears without the highest grade of workmanship. Most gear noises are caused by faulty workmanship. There are frequently many excuses for poor workmanship. Such words as "harmonics," "resonance," and "sound amplification" are often used in connection with gear noises, but in the author's experience more than 90 per cent of the trouble has been due to inferior workmanship. The word "workmanship" here applies not only to the gears themselves but also to the housing, bearings, shafts, alignment, and installation. In this connection it should be particularly noted that antifriction bearings are sometimes faulty.

To deal with the details of workmanship thoroughly would need a lengthy paper. It is therefore only possible to deal with the more common faults in a somewhat cursory manner.

Gear makers who have gained a reputation for high-quality high-speed gears have discovered that a relatively high degree of precision is necessary in the manufacture of all elements of gears and their attachments. Quality of workmanship and material in this case covers more than general precision in manufacture, for the degree of finish or polish on the tooth surface must be of the same kind as that obtained in the manufacture of precision ball and roller bearings.

It is not sufficient to take what is termed a "clock indicator" of an ordinary kind and rely on it for indicating inaccuracies. Instruments of the highest degree of precision must be obtained and used skillfully. It is not satisfactory to check the alignment or level of shafts by the kind of instrument found in the average machinist's kit. It is desirable to use precision levels indicating to 0.0002 in. per ft. Dial gages which will actually indicate 0.0001 in. must be used. It is not sufficient merely to buy a ten-thousandths dial gage from a reputable maker. Such a gage must be carefully used and checked from time to time to make sure that it is really sensitive. The use of line bars for checking parallelism of axes or correct angularity of axes, when gears operating on nonparallel axes are being dealt with, must be very accurate.

Gear-cutting machines of the highest grade, and cutting tools accurate to within very close limits are necessary. To insure uniformly good results, nothing can be left to chance in the matter of workmanship. Every element must be checked thoroughly, and to do so usually entails checking everything by three separate and reliable methods. Gear teeth must, of course, be cut concentric to the axis on which the gear will run, and the pitch must be accurate. Preferably, the largest in-



A MALLER GEAR BEING TESTED FOR SILENT RUNNING AND FOR TOOTH CONTACT

accuracy in pitch should not be more than ten seconds of arc. The tooth contours need to be precise. Careful observations indicate that an error of 0.0001 in. is, in some cases, too much. Gears having helical teeth seem to be essential and it is nearly as important that the helixes be as accurate as the tooth contours, and it must be especially noted that they must be accurate in relation to the axis on which the gear will actually operate. It is equally important that the tooth surfaces be smooth.

The foregoing requirements, when carefully considered, will soon convince the experienced technician that the only way to fulfill them is by a final lapping operation. This seems essential whether the gears are hardened or not, and it is also essential whether or not the gears are ground. According to the present state of the art it seems that the grinding of gears, while helpful and in some cases even desirable, does not provide the necessary high degree of precision. A final lapping process seems to be necessary. The lapping of gears is at present an art and will probably remain so to some extent. While it seems practicable to polish, by means of an abrasive wheel, a cylindrical, conical, or flat surface, it does not yet seem possible to finish with the requisite degree of precision a helicoidal surface by any method other than lapping.

The foregoing remarks are made having in mind very high-speed gearing which has to carry relatively heavy loads for its size. Lower-speed gearing will run silently in a practical sense when not made quite so precisely, but, nevertheless, a relatively high degree of precision is desirable for all gearing, even that operating at the lowest speeds.

MOUNTING OF GEARS

The utmost precision in the manufacture of the gears themselves can be nullified by inaccurate mounting. The relative positions of the shafts need to be as exact as the gearing itself. It is obviously useless to make a pair of gears to operate on exactly parallel shafts and then to mount the shafts out of parallel. It is equally futile to expect a pair of gears to operate on shafts, the axes of which should cross at an exact right angle, which are set at some other angle. Similarly, gears which are made to operate on shafts whose axes intersect, cannot operate properly when mounted on shafts the axes of which are offset.

Although the manufacture of practically silent gearing is somewhat exacting, it is not quite as difficult as it is sometimes believed to be. Intelligent, painstaking effort will bring surprisingly good results. Careless, slipshod work and merely trusting to luck will result in nothing but grief and trouble. Halfway measures will usually result in about one good gear out of six, the remainder being indifferent or poor. The utilization of the best present-day equipment and methods will result in about 80 per cent excellence, 15 per cent moderate results, and the remainder just passable.

LUBRICATION

No gear will run silently under load unless it is reasonably well lubricated. The question of lubrication in reference to design has already been dealt with. It is only necessary to add that clean lubricants in a clean housing are necessary. It is obvious that precision gearing will not operate properly if there is grit between the teeth. It is further obvious that if a lubricant which is too thick is used, the gears will "track," and the lubricant will not be properly spread over the teeth. If a very thin lubricant is used, or if a relatively thick lubricant is overheated, the lubricating qualities will not be satisfactory.

OVERLOADS

Those who have had experience in testing gears for silence are well aware that any particular pair of gears may run silently at certain loads and become noisy at other loads. Some gears will run perfectly silently at no load but will make a noise when carrying only 10 per cent of the designed load. Others for example, will run silently at 50 per cent of the load and noisily at 100 per cent of the load. Some will run silently at full load and may be noisy at 50 per cent overload. Others will run silently at any load which does not result in damage to the tooth surface or to the shafts and bearings. It is therefore desirable when investigating a noise complaint to make sure that the gear is not overloaded, or that it has not been overloaded and damaged thereby.

GEAR SPEEDS

All the remarks hitherto made in this paper are intended to apply to all kinds of gears at all practical speeds. It is the present-day custom to talk loosely of low-speed gears, medium-speed gears, and high-speed gears, also to refer to industrial gears, turbine gears, street-car gears, and automobile gears. While speed undoubtedly makes a difference in the noise of gears, really precise gears, properly designed, will run quietly at full load up to very high velocities. There are many sets running satisfactorily up to 12,000 fpm, and there seems no good reason for not running such gears up to 18,000 fpm.

It is the author's opinion that gear makers who are troubled with noise will overcome it only when they have decided to pay the price in terms of capital expenditure and intelligently directed effort. It is barely necessary to add that unless they are philanthropists they will have to get their customers to pay the equivalent price in currency.

PROCESS INDUSTRIES *and* RURAL STABILITY

By W. R. WOOLRICH

DIRECTOR, AGRICULTURAL INDUSTRIES DIVISION, TVA

IN 1862 Congress passed the Morrill Act creating the funds for agricultural and mechanical colleges in the several states of the Union. It was signed by President Lincoln.

There can be but little doubt but that the framers of that act had in mind that these Land-Grant colleges and universities established in each state should center their attention toward the training of young men for the development of the resources of each of the several states. Since the colleges were definitely established for joint instruction in agriculture and in the mechanic arts, the essential companionship of these two was evidently recognized in this Act of nearly three quarters of a century ago.

The history of the growth of the several land-grant institutions does not indicate that the functions of the schools of mechanical arts and the schools of agriculture have been closely interrelated. While usually on the same campus, they have drifted far apart in their objectives and in their educational and research philosophy. In some instances their programs have become decidedly dualistic.

In 1887 the Hatch Act made available to every state and territory a federal grant of $15,000 annually for agricultural experiment station research projects. This amount was increased in 1906 by the Adams Act to $30,000 and the limitations of the the original act were considerably extended. In 1925 the Purnell Act made available an additional $60,000 for each state and territory and granted considerable extension to the fields of proposed activity which these research funds might include.

Contributed by the Process Industries Division and presented at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Finally, in 1935, the Bankhead-Jones Act was approved, making another increase in the funds available for agricultural experiment station activity.

During this growth and development of the agricultural experiment stations in solving problems relating to agriculture, the engineering colleges have received practically no federal support for engineering experiment station projects. However, many of the researches pursued by the land-grant college engineering experiment stations have not been directly related to the development of the resources of their respective states. Furthermore, the function of training men for directing research and developing new local industries for the creation of the common wealth of the state has received far too little consideration by most land-grant schools of engineering.

During the building or development period of America, while resources were abundant, such a type of training was acceptable in part. But today the states of the Union must turn their research to the conservation and to the creation of wealth from the more inexhaustible resources of nature.

NEED FOR COORDINATION OF INDUSTRY AND AGRICULTURE

There is a fundamental need for agricultural and engineering experiment stations to go down the road together in finding new ways of using farm products, new methods of adding soil fertility, new equipment for improving country life, and new devices for turning the destructive forces of nature into agencies for the public good. They will thus direct new forces toward the stabilization of both industry and agriculture for their supporting regions.

During the period of engineering-research inactivity in

FLAX CROP HARVESTED WITH MODERN MACHINERY ON THE SOUTHERN HIGHLANDS

(There are many research investigations essential to economic production of linen cloth from this crop. The interrelation between crop practice and quality of finished cloth involve both engineering and agricultural research.)

CONTROL SHED FOR CLARIFYING AND TREATING SORGHUM SYRUP

(Without increasing the national production, the quality can be so greatly improved by employing engineering and chemical control, but using the old types of pans and presses, that the rural income from this crop can be readily increased thirty per cent.)

matters relating to agriculture, the national percentage of people living under rural conditions decreased to 23 per cent. The United States became more urbanized than any nation that had ever carried on with any appreciable degree of permanence. Today, 77 per cent of the people require a daily supply of fluid money, while a century ago only 15 per cent needed it.

Thousands of workers were encouraged to stop producing their own livelihood on small tracts because they could buy so cheaply. This brought about a greater and greater demand for fluid money among the laboring and middle classes, and a greater and greater concentration of wealth and investment among the dealers in goods.

When industrial work stopped, these laboring and middle classes discovered they had given up their independence, and to a large extent the implements by which they could produce their own subsistence. When the normal flow of money required to feed their families stopped, they were thrown upon a bare city lot and an overburdened government for food, raiment, and shelter.

It was under these conditions that the mass-production system fell down and the pawn was the great mass of laborers and people dependent upon the weekly pay check for existence.

During its early history, while the United States was a debtor nation, it was not a serious matter that the industrial wealth was concentrated on or near the great national waterways. So long as extensive construction was under way throughout the Middle West and while natural resources were abundant, people could readily carry on in spite of such a concentration.

But as the natural resources were "mined" out and the vast rural areas settled down to an earnest endeavor to earn a living from depleted soils, then the concentration of industrial wealth and activity became a real hazard to the livelihood of the thousands who depended upon industry for their entire existence.

WHAT SHOULD BE THE BASIS OF OUR ADVANCE?

It is advisable to approach the national conservation program by regions that have many problems in common. In the internal areas of the United States the watersheds of the larger navigable streams offer a satisfactory unit for activity. A common-sense basis for advance becomes, then, the conservation of each of the river watersheds.

In any such area development the problems divide themselves into those of the land and water under federal or state control and under the direction of private owners. American industry is concerned with both.

The navigable streams and their important tributaries are under federal and state control. Effective water control of the navigable streams involves the problems incident to the development of the complete watershed in relation to navigation and to flood control. This in turn requires definite information on rainfall, stream flow, and silt movement. Coincident with this are the necessary investigations of the desirable locations for controlling dams and lockways.

America has had to take flood control very seriously in recent years. Since 1928 we have spent more than three hundred million dollars in trying to control the lower Mississippi River. Information is desirable to determine whether it would not be more economical to spend a considerable portion of the flood-control money of any watershed on tributaries nearer to the source rather than to direct such a large portion to the areas near to the river's mouth.

Sufficient study should determine the relative permanency of the two methods. Usually, the control of the headwaters by dam construction is relatively permanent—a permanency that can be expressed in terms of hundreds of years. These are only a part of the problems involved in the federal and state control of the national waterways. The destructiveness of waterways when uncontrolled and their usefulness when properly harnessed will always attract the best engineering minds to solve the problems involved.

But much more of the effort of mechanical engineers will probably be given to the problems relating to the conservation of the watershed through a control of water on private lands. This control will be largely through absorbent cover crops, forest undergrowth, and similar rainfall-run-off preventative measures so capably practiced by nature herself before man tore up the soil cover and turned loose millions of tons of soil for river silting and hillside depletion.

THE PROBLEM OF PRIVATE WATERSHEDS

The problems of these private lands that comprise the watershed may be divided into three general classes: Submarginal lands, farming areas, and urban areas.

Submarginal lands might be considered those areas that

are too steep, too rocky, and too wet to produce other than forests, parks, and wild-life preserves.

The problem of taking submarginal lands out of production involves the removal of population. The many attempts made to move populations during the past five years have indicated the seriousness of any attempt to induce people to migrate from established home conditions by any mass movement. It will require the most carefully directed management principles and common-sense type of human engineering to shift satisfactorily old home owners into strange areas.

The readjustment of the farm areas often requires the changing of present cultivated crops to those that will preserve the fertility of the area. In many sections of America there has been a growing tendency toward the cultivation of row crops, such as corn, cotton, and tobacco. The consequent loss of cover soil from such lands is often from 50 to 60 tons per year per acre. Had the same areas been used for grain cover crops, the soil loss would have been only a small fraction of this amount and in the case of grass pasture lands would not have been more than one to two tons per acre per year.

Evidently, then, there is a close relationship between water and soil-conservation problems. Not only does the growing of corn, cotton, and tobacco increase the loss of land by rainfall and flood, but it fills the dams with silt and the river beds with sand-bar obstructions. A program of successful dam construction then necessarily involves coincidentally a development of the grain and grass type of agriculture for dairy and beef production.

Such a change requires essential readjustment in farming practices of private individuals so they can continue to provide incomes equal to those they realized under the old program. The investment required to plant and harvest a crop of corn is often less than one fourth the investment required to plant and harvest an equal area of cereal grains.

Incidentally, these changes in crops involve a change in diet of both the livestock and of the families related to the land and to some extent it brings about a change in their whole philosophy of life.

In urban areas greater readjustment will necessarily be essential as the improvement in rural conditions encourages more people to withdraw from the crowded urban areas and seek relief from taxation, noise, dirt, and city restrictions in the suburban and satellite sections.

ENGINEERING PROBLEMS ARISING COINCIDENT WITH A LAND- AND WATER-CONSERVATION PROGRAM UNDER PRIVATE OWNERSHIP

Engineers should be vitally interested in five major problems that are involved in this readjustment of all three types of these land areas. These five major problems are: (1) Rural electrification extension; (2) plant-food production; (3) development of new types of agricultural equipment; (4) establishment of service industries to meet the new needs; and (5) design and research leading to new processing industries.

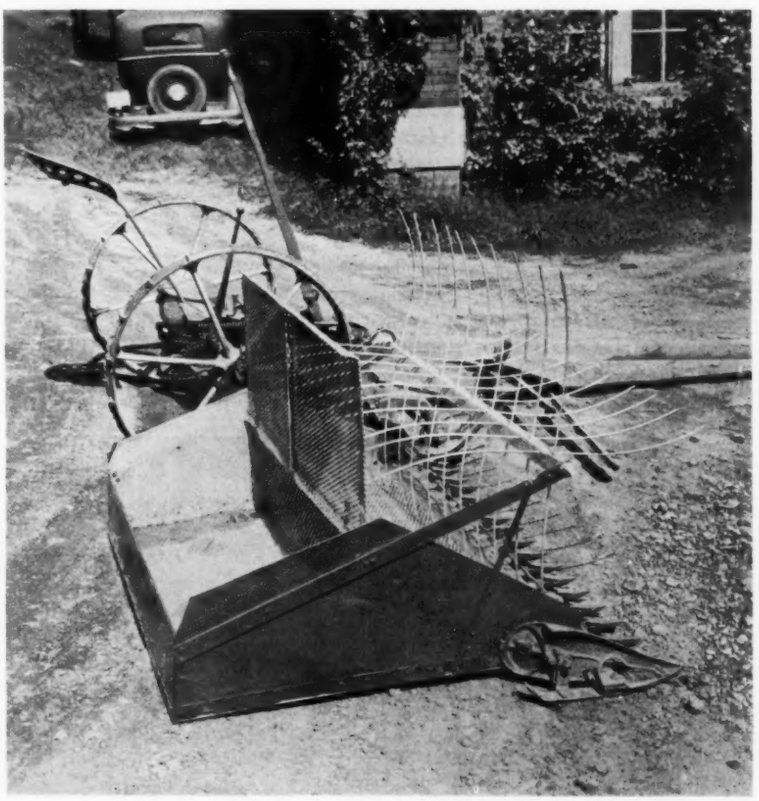
Rural Electrification. One of the by-products made available by a program of land and water control through dam construction is the production of electricity. Electricity is one of the most effective factors in making suburban and rural life more attractive. Its effect is far-reaching in that it encourages the dispersing of mass population from the urban centers and creates a new stimulus toward family development on semirural soil.

New uses for electricity to make it assist in raising the farm income are more essential today than are devices that were designed for city folk. The successful farm operator needs simple rugged electrical equipment that will do new things effectively. Rural electrification, in its larger sense, should meet essential farm requirements first. Luxury devices can follow as profit-producing equipment assures an increased income.

New Plant-Food Products. The creation of new plant-food products to protect the watershed and encourage a wider diversity in living conditions and products is a problem that has received too little attention during the past century.

Up to the present time plant foods have been generously dissipated in American life. Fortunately, in the case of nitrogen, lime, and potash, this is not very serious. We have twenty million tons of nitrogen available above every square mile of the earth's surface. We have millions of tons of lime widely distributed over the several states. Potash has been far more liberally distributed over the United States than was previously supposed. The enormous deposits of potash in the Carlsbad area and similar recent discoveries has made America independent of Europe for her potash supplies.

The limiting element of plant food in the United States is phosphorus. We cannot get phosphorus out of the air; there are no commercially available sources in water reservoirs, and the national supply in mineral deposits is limited. America must come to recognize that phosphate deposits are the "life blood" and the permanence of these phosphate deposits is to a large measure a limiting factor in the permanence of life on this



SEED HARVESTING ATTACHMENT FOR LESPEDEZA

(An engineering experiment station and an agricultural experiment station cooperated in evolving this seed harvester to replace several designs of cross-road-blacksmith-shop makeshifts. It is 100 per cent more effective than the originals.)

continent. Animals and human beings use large quantities of phosphorus, thus it will be an ever-universal need to our soils.

The dams that make sources of power available can be used as a refining force of available phosphate deposits to change these phosphate compounds, usually found in a form not readily available to plant life, to such a form that they can be used by plants and then passed on to the human and animal inhabitants of the nation through the various cereals, foods, and meats.

New Agricultural Equipment. The development of new agricultural equipment especially suited to each area is essential to a water-land conservation movement. American agricultural-equipment development has been largely that of two extreme types—that for gardens and that for large farms. Furthermore, the inertia of high specialization in farm equipment has not encouraged the growing of new types of crops.

The development of lespedeza-seed-harvesting equipment to lend a new impetus to the general distribution of this most valuable Asiatic legume is an example of what can be done by the coordination of activities of engineering experiment stations and agricultural experiment stations.

The design and construction of rugged fertilizer distributors to provide an effective metering of the new highly concentrated phosphate plant foods on small farms is another typical example of the engineer and the agriculturist together solving the needs of modern small farms within the walls of an engineering experiment station.

Community Service Activities. A fourth engineering phase of this closer association of engineers with agriculturists is that offered in the development of community service activities.

The extension of farm refrigeration practices is one example of new opportunities for refrigeration engineers. We have done a very sketchy job in introducing to rural America the practical uses of refrigeration. The progress in the refrigeration of farm and dairy products has lagged far behind the adaptation of city types of refrigeration units to the country household.

Similarly, the dehydration of farm perishables, the successful drying of hay crops of small farms in areas of heavy rainfall, the development of high-speed, satisfactory, universal feed and meal grinders of fractional-horsepower size are all problems that the mechanical engineer and the agriculturist can solve most successfully when they work together.

Research in New Industries. The Tennessee Valley Authority has encouraged a number of the southern engineering-college experiment stations to cooperate with existing agricultural experiment stations in the solution of these problems with some noteworthy success.

The American Society of Mechanical Engineers can make a definite contribution through its Process Industries Division to the water-land conservation of any area by assisting in solving the problems of the processing of farm crops. This can probably best be done in cooperation with the several engineering experiment stations and the many agricultural experiment stations. As an example of the approach to this type of problem, the cooperative effort in developing new procedures in cotton-seed and soy-bean processing can be cited.

It is essential that most of the soy-bean and cottonseed meal be retained in the area where it is produced. Both of these products have a high fertilizer value and cannot be removed from any watershed area without some soil depletion. The combined engineering researches of the University of Tennessee engineering and agricultural experiment stations, the Tennessee Valley Authority, and the Engineering Foundation are being directed with some success in this research. The history of the depletion of the South's fertility by the exportation of cotton-seed is a past chapter of no mean consequence—and these four agencies are now turning toward its solution.

Again, there might be cited such valuable projects as the investigation of new methods of freezing southern fruits, new devices for preserving syrups, new methods of curing Burley tobacco, and new equipment that will successfully prepare millions of pounds of farm-grown walnut meats for the more exacting market channels. All of these offer commanding channels of research for young mechanical engineers and will lead some to develop an industry under their own direction.

And in this accomplishment there will come a solution to some of the problems of rural stability. Many counties of the rural United States have from 400 to 1800 available young gainful workers not now needed for either industry or agriculture. The engineering profession should proceed to encourage more young men to enter the ranks as producers of jobs instead of mere aspirants for a position. A century ago a large percentage of the educated men definitely planned on creating some business enterprise that would employ numbers of people. The philosophy that encouraged them to create new enterprises must again be inculcated into our engineering-college youth to replace this position-seeking urge that has made our technical men followers instead of leaders.

The diversity of industrial enterprise in any area, accomplished by the creation of a goodly number of service, equipment, and processing industries related to the products of the soil, will bring a stability to both the industrial centers and the rural population that will lend to the United States a degree of that rural stability so noteworthy in Switzerland and the Scandinavian countries.

A LOW-COST HAY-DRIER LAYOUT
(Effective hay drying will conserve millions of tons of animal feed when properly developed.)

A LONG-RANGE PATROL SEAPLANE

(Holder of long-distance non-stop seaplane record, Panama to San Francisco. Its outstanding feature is the retractable wing-tip floats.)

REVIEW OF AERONAUTICS

Progress During the Past Year as Reported to the A.S.M.E. Aeronautic Division

FOR SEVERAL years it has been customary for the Aeronautics Division of The American Society of Mechanical Engineers to present a report on progress in aeronautics prepared by several authorities representing various branches of the field covered by the Division. The following reports, some of which have been slightly abridged, were presented at the A.S.M.E. Annual Meeting, New York, December 2–6, 1935.

AERONAUTICAL METEOROLOGY[1]

During the year there has been comparatively little advance in meteorology along strictly aeronautical lines. Naturally, much of the study being made constantly in general meteorology is, directly and immediately or indirectly and ultimately, useful for aeronautical purposes although not conducted with this end in view.

In this category lies any attempt to secure more widespread international cooperation in the gathering and dissemination of daily weather data. An international congress of meteorologists held at Warsaw during the summer of 1935, attended by Dr. W. R. Gregg, chief of the U. S. Weather Bureau, did much to promote this cooperation, and to bring nearer the goal of a reasonably complete and world-wide daily weather map of the northern hemisphere. The importance of such a map in increasing range and accuracy of weather forecasting can be readily understood.

A definite advance has been made also in the production of an American daily weather map, extending from the eastern Pacific Ocean across the North Atlantic to include western Europe, and reaching subarctic latitudes. This map is not published, but is available in manuscript form at certain centers for meteorological research. Its importance lies largely in the fact, beginning to be more widely appreciated, that the behavior of the weather in eastern North America often depends fully as much upon that over the North Atlantic as upon the commonly understood movement of disturbances from the west and south. A few more years of accumulation of oceanic data should enable us to discover the key to some otherwise inexplicable eastern American weather.

U.S.S. "SARATOGA" AIRPLANE CARRIER

Stratosphere and substratosphere flying seems no nearer realization than last year, and remains in an experimental stage. Stratosphere penetration has been brilliantly accomplished once more by the Army-National Geographic Society ascent, establishing a world altitude record for balloons—or for anything bearing passengers. The important scientific data secured in this ascent may not be immediately available, but are certain ultimately to contribute needed information regarding a part of the atmosphere in which we hope before long to do considerable flying over long-distance courses.

The use of the air-mass analysis method of making short-range forecasts has been expanded and intensified, particularly by air lines. It has been severely criticized in certain quarters, and as strongly defended by its advocates.

[1] Prepared by J. Edmund Woodman, Lecturer in Aeronautical Meteorology and Navigation, Guggenheim School of Aeronautics, New York University, and Director, New York University Meteorological Observatory, New York, N. Y.

Illustrations on pp. 431–433 are from official photographs, U. S. Navy; those on pp. 436–439 are from official photographs, U. S. Army Air Corps.

OBSERVATION SEAPLANE MAKING ROUGH-WATER LANDING
(This type of plane is used for catapulting from cruisers and battleships, for observation and scouting purposes.)

Regulations restricting and defining its use are reported to have been issued by the Department of Commerce, involving reference of data and deductions to the chief U. S. Weather Bureau official stationed at the particular airport before planes are permitted to take off in doubtful weather. It is evident that improvements are still possible in its use for the eastern part of the country, to secure a much needed advance in accuracy and time range for such forecasts.

Fog and other impairments of visibility continue to be perhaps the chief foes of flying. Beam-flying blind is possible only as it focuses upon the comparatively small number of airports along airways, and this will in all likelihood be the case for an indefinite period. It has apparently been necessary to restrict blind flying, taking off, and landing, by planes not involved in scheduled use by air lines, when in the vicinity of airports operating beams. This appears to bear heavily upon private and contract flying; but it may be necessary for a time, and may ultimately lead to a happier solution of the difficulty.

Visibility today presents the most important meteorological problems, solution of which would be of most immediate and direct aid to aeronautics. The U. S. Weather Bureau and at least one nongovernmental research body are actively engaged in studying its unsatisfactory status and in attempts to develop new measuring standards, to devise new angles of attack, and finally to separate as completely as possible the viewpoints of the meteorologist and the pilot. The pilot and the ordinary weather student require different sets of data. The latter is interested chiefly in the real optical quality of the air, unaffected by such things as industrial haze. Both viewpoints are under close study at the present time; and it is expected that the first fruits of these studies will soon be available.

An aspect of the general problem not given the attention it should receive is that of vertical visibility, upward and downward, and of oblique visibility. The relations—or absence of any—between these and between them and ordinary horizontal visibility require much study of facts. Such data were impossible to obtain in quantity and at strategic centers prior to the inauguration of the daily laboratory plane flights alluded to in last year's progress report. Their importance is obvious.

A letter from the chief of the U. S. Weather Bureau last spring says: "The Weather Bureau contemplates the recording of vertical and oblique visibilities in its airplane weather observations next fiscal year. At the times when vertical and oblique visibility observations are made the observer on the ground will record horizontal visibility at the time of take-off and approximately the time at which the maximum elevation is reached. These horizontal visibility observations will be made according to the International Scale. They will be recorded for each of the cardinal directions."

That is probably the only way in which an immediate attack can be made upon this extremely important problem, and bids fair to yield data of great value in solving, to some extent at least the present confusion and difficulty in measuring visibilities in up-and-down directions.

A comparatively recent invention that promises much for aeronautics, although developed especially with maritime use in view, is a device for sending completed weather maps to an indefinite distance by radio as a complete picture. Its availability for air line use is still to be demonstrated; but it is certain that its wide application to flying will do much to add to the safety of line flights.

AERODYNAMICS[2]

There have been no startling changes in aerodynamic design during 1935. Many detailed improvements have taken place, notably in the general cleaning up of the airplane and an increasing tendency to larger aspect ratios. The tendency toward higher aspect ratio is due to the need for longer range or higher cruising altitudes, or both. This tendency has been accentuated by the use of higher wing loadings and the necessity for holding the induced drag as small as possible. No notable improvements in high-lift devices have occurred. Some manufacturers have used modifications of the simple flaps, but the results of their attempts have not as yet been disclosed.

The laboratories, and especially that of the National Advisory Committee for Aeronautics, have spent much effort in trying to perfect lateral-control devices that will permit full-span flaps. The N.A.C.A.'s slot-lip aileron seems to be the most promising, but is still to be tried in service, although preliminary flight tests are promising.

The N.A.C.A.'s spinning tunnel will enable American manufacturers for the first time to obtain data on the spinning characteristics of their designs in advance of construction, thus removing one of the greatest worries of the designers.

Another important development is the new N.A.C.A. airfoils These, and especially the 23,000 series, have high lift, low drag, and practically zero pitching moment. Flight tests and wind tunnel tests on tapered wings of this family substantiate the laboratory tests on the straight airfoils.

The desire to get the maximum possible ram for the car-

[2] Prepared by A. L. Klein, California Institute of Technology, Pasadena, Calif.

buretor intake, and the elaborate ventilating systems on transport airplanes have introduced the aeronautical engineer to a new field of aerodynamics, namely, flow in ducts. Some of the newer airplanes show carefully designed carburetor intakes in keeping with known, but hitherto unused, principles.

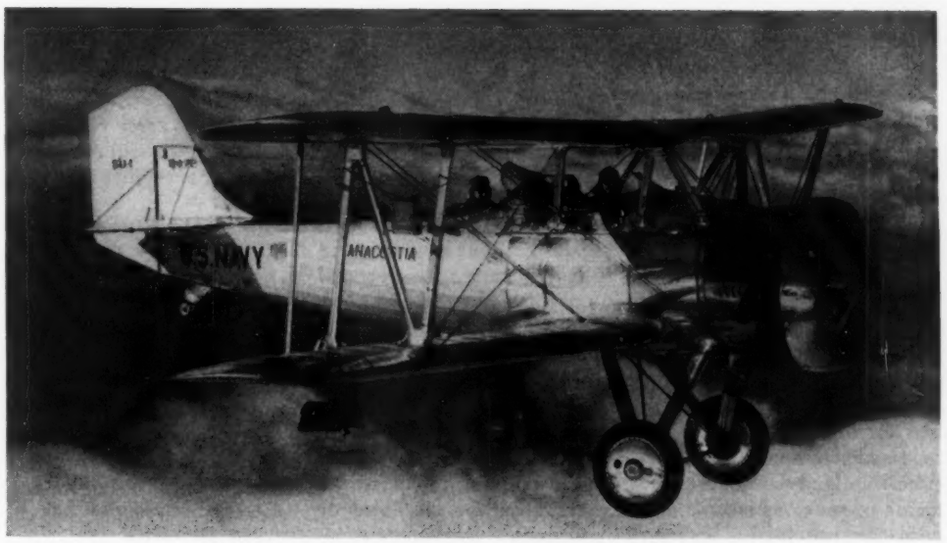
The continuously variable pitch propeller has brought with it a whole new field of problems. This device has made necessary studies on the best manner of operating the propulsive unit, and has complicated the pilot's problem further by making it possible for him to obtain a given power from his engine with various combinations of engine speed and manifold pressures.

At the present there is no commonly accepted solution, but work is in progress which should soon lead to a standardized procedure. Certain manufacturers have, during the last year, equipped airplanes with propeller brakes in order to reduce the drag of an idling propeller and to prevent destruction of the engine. A stopped propeller usually has more drag than an idling one. However, the second purpose may still be worth while if the weight of the brake mechanism can be kept within reason. The feathering of the propeller blades has been shown to be a better solution.

Many studies have been made during the past year on high-altitude performance. These studies show a great increase in cruising speeds to be obtained by flying at high altitudes if the distance to be traversed is sufficiently great. They have shown that even with airplanes of existing types increased operating speeds could be obtained if it were possible to operate at these altitudes. Practical results await the development of airplanes with oxygenated or supercharged cabins.

In the laboratories progress has been made during the past year in a better understanding of the problems of turbulent flow. Work on turbulence and roughness has increased our knowledge in these fields.

Other very interesting scientific work has been done, particularly in England and at Langley Field, on the attainment of abnormally high lift when airfoils are suddenly placed at large angles of attack. These developments verify flight-test data and also the Bureau of Air Commerce rules on the gust conditions.



A VOUGHT SCOUTING PLANE ON AN AEROLOGICAL FLIGHT

(The recording instruments are located in the metal container secured to the inter-wing struts. The bracket under the lower wing is for flares for night landings.)

AIRPLANE DESIGN AND CONSTRUCTION[3]

Progress in airplane design and construction in 1935 was in keeping with that of the previous few years, though some expected that the speeds of standard civil types would have increased much more. Structurally, improvement was made, as shown by the increased ratio of useful load to gross weights, which has exceeded 50 per cent in the cases of some flying boats with high wing loadings. Progress was also made in the development of details tending to reduce operation costs, simplify maintenance, facilitate manufacture, and increase safety.

[3] Prepared by Richard M. Mock, Fokker Representative at Douglas Aircraft Co., Inc., Santa Monica, Calif.

The trend continued toward increase in the number of cantilever monoplanes of low-wing multi-engine design. In England, the stronghold of the biplane, the low-wing cantilever monoplane became the standard small civil type, and the number of larger planes of this type increased as well. In the United States, except for military and a few small types, the biplane practically disappeared.

Metal structures continued to increase with aluminum alloys as the standard material. The use of stainless steel continued; but its growth was not as rapid as that of aluminum alloy for stressed-skin structures.

The trend was definitely toward higher useful loads, with high pay loads and increased range. To achieve this, efforts were exerted toward improving the structure, though the result was chiefly an increase in the size of airplanes developed and projected, as well as higher wing loadings.

SPEED

Increase in speeds was not as great as in previous years when the N.A.C.A. cowl and retractable landing gear came to be common practice. Recent increase has mainly resulted from aerodynamic refinements achieved by improved body forms, elimination of external structure, reduction of interference, and decreased wing areas which were accompanied by higher wing loadings. In 1933 and 1934 the United States forged ahead of Europe in the development of high-speed commercial airplanes. However, European manufacturers brought out designs in 1935 that were as fast; and in some cases they were faster than the American types which they resembled. It is interesting to note the resemblance that these new European designs bear to American types of one or two years before. Examples are the two-engine, low-wing, retractable-gear types of Boeing, Douglas, Martin, and Lockheed, brought out in 1932 and 1934, which were almost duplicated in 1935 by the Fiat G-18 and Caproni 123 in Italy, the Avro 652 and Bristol 142 in England, the Bréguet Wibaut 670T and Potez 62 in France, and the Junkers JU-86 and the Heinkel 111 in Germany.

By great attention to detail and without excessive horsepower Dick Palmer produced the Hughes special racer which, in September, 1935, established the world's speed record for land

planes of 351.79 mph. A few days later Major Seversky flew an amphibian of his own design at 230 mph, establishing a new amphibian speed record.

The Hughes racer was a low-wing monoplane with a fully retractable landing gear. The dural monocoque fuselage was almost completely filled with fuel tanks, which, with the tanks contained in the plywood-covered two-spar wing, gave the plane a range of about 1500 miles with the 700-hp Pratt & Whitney twin Wasp Jr. engine.

The Seversky was also a low-wing design; but in addition to the dural monocoque fuselage, it had a multispar all-metal wing, below which were a pair of amphibian pontoons.

Only one new American commercial transport landplane type was announced in 1935, the Douglas DC-3 or DST, an enlarged version of the well-known DC-2. This plane made its first few flights in December. The estimated performance was approximately the same as the DC-2 though the useful load and accommodations were considerably improved. Other American landplanes improved in speed through minor refinements of previous models. However, in Europe the speed of civil transport planes increased appreciably. Notable are the world's records established in September, 1935, by the Italian Savoia S79, a low-wing design with three Piaggio 600-hp engines, one in front of the fuselage and the others in the leading edge of the wing, all with full N.A.C.A. cowling. Various payloads were carried a distance of 621 miles at 242.1 mph, and the same loads 1242 miles at 236.7 mph. The Douglas DC-1 previously held these records at 191 mph. However, because of its higher useful load, the Douglas retained its records for 3105 miles with loads up to 4400 lb at 169.4 mph.

The trend toward larger airplanes was exemplified by the Boeing 299, four-motor low-wing bomber developed for the U. S. Army Air Corps. Though its performance was not announced, it was reported that it flew the 2100 miles from Seattle to Dayton at an average speed of 233 mph.

POWER PLANTS

Power-plant arrangements for multiengine machines was definitely toward two- and four-engine arrangements; while in Europe the two-, three-, and four-engine arrangements continued to be produced, with Russia building planes with five, six, and eight engines. The choice of the number of power plants was influenced by the size of power plants available with engines of 800 to 1000 hp being the maximum in use anywhere in regular service.

It became standard practice to mount wing engines in the leading edge of the wing with full N.A.C.A. cowling and pressure baffles. Practically no development of engines for installation within the wing with a shaft drive was noted. However, on the Dornier DO-18 Diesel-engined flying boat the rear of the tandem engines drove the propeller by means of a short shaft.

In general, four-cycle gasoline engines with carburetors and poppet valves, prevailed in the United States. In England much progress was made with sleeve-valve, radial engines; while in Germany work continued with the Junkers Diesel. Two airplanes equipped with these Diesels were announced during the year—the Junkers JU-86, two-engined smooth-skin landplanes, and the Dornier DO-18, two-engined flying boat.

Supercharging for civil airplanes increased, giving critical altitudes of 10,000 to 15,000 ft, though operational altitudes continued to be below 12,000 to 14,000 ft. However, many studies were made of high-altitude flying, and one firm made a series of informatory flight tests releasing oxygen into the cabin at altitudes above those normal for human comfort.

FLYING BOATS

Perhaps the most noteworthy progress in design during the year was in flying boats. The Martin 130, four-engined *Clipper* will be remembered as the first practical commercial flying boat designed to carry passengers over any ocean. The Martin was the first successful American attempt in the development of stub wings or sea-wings for transverse stability of a flying boat on the water.

In the Martin were many progressive features, such as corrugated bottom for the hull as well as the sea-wings. In both the sea-wings and the hull the outside skin was utilized for the gasoline tanks. By such courageous features, in combination with an externally braced wing heavily loaded, the Martin had a ratio of useful load to gross weight of 51 per cent. In addition, this tank construction lowered the center of gravity considerably, thus improving the stability of the plane on the water.

Also worthy of note in this same field was the Sikorsky S-43, two-engined amphibian following the general lines and arrangements of the four-engined Sikorsky S-42 brought out the previous year. The S-43 carried more than 6000 lb useful load with two 750-hp engines, and had accommodations for a crew of three and 16 passengers.

Another flying boat completed in 1935 was the Consolidated XP3Y-1 of the U. S. Navy, which in October established a long-distance flying-boat record of 3300 miles air-line distance, and 3450 miles broken-line distance. This was a two-engine high-wing boat with side floats retracting into the wing tips.

Also completed during the year was the Fairchild single-engine amphibian developed for Pan American Airways. A notable feature was its landing-gear retracting mechanism for folding the wheels high up into the wing.

An interesting flying boat was the British Short R.24/31 twin-engine gull-wing monoplane flying boat. In France there was completed toward the end of 1934 and tested early in 1935 the six-engine 32-ton Latécoere 521 (6 × 860 hp) flying boat which unfortunately crashed before being put into service.

LANDPLANES

In December the Douglas DC-3 or DST made its first flights. Basically it is the same as the DC-2. However, the wing span was increased improving the aspect ratio. By increasing the gross weight to 24,000 lb the wing loading was increased, as was also the power loading even though 1000-hp engines were used. The fuselage was considerably enlarged this being the first American landplane designed originally as a sleeper. As a sleeper it is known as the DST and has accommodations for 14 to 16 passengers while as a dayplane it is known as the DC-3 and carries 21 to 24 passengers. In spite of the increased wing and power loadings the performance was about the same or slightly better than the DC-2 and the handling characteristics considerably improved. Most notable improvement in connection with the DC-3—DST was increase in possible operating revenue. Due to the increased accommodations and payload this was almost double that of the DC-2 while the operating costs went up but little.

In the small-plane class more retractable landing gears, wing flaps and fillets appeared than ever before, apparently indicating that the small-plane manufacturer was taking advantage of the air-transport manufacturers who can afford to spend much more on research.

The U. S. Department of Commerce continued to foster the development of a small, cheap airplane with greatly simplified flying characteristics. However, none of these got into production in 1935, though experimental planes were delivered during the year, such as the Hammond Y, Weick W1-A, Curtiss-Wright Sparrow, and the Waterman Arrowplane (a tailless

design). All except the Curtiss had tricycle landing-gear arrangements to permit landing without leveling off. For 1935 this could be considered quite radical.

Also sponsored by the Department of Commerce in an effort to develop the cheap power plant were the converted automobile aircraft engines of Fahlin (Plymacoupe using Plymouth engines) and Arrow (Arrowplane with Ford V-8 engines).

In the light-plane class, the French "Pou du Ciel," or Sky Louse attracted much interest all over Europe. It was a light-plane type designed for home construction. It is believed that about 50 were built during 1935.

AUTOGIRO

The direct lifting autogiro made its appearance during the year, as did the wingless autogiro with the folding three-blade rudder. These machines are faster than the earlier designs and are rapidly overcoming many of their early objections.

AIRCRAFT POWER PLANTS[4]

The increase in output, per unit of displacement and weight, which has been evident in American aircraft engines during the past several years, continued in 1935. Improvement in cooling has been the principal factor making this possible. Fuel manufacturers have recently indicated ability to supply fuels of even higher antiknock value than those at present on the market, and investigations of the possible increase in output, when such fuels are used, have yielded significant results (1).[5]

The increasing specific output of service engines has emphasized the problem of crankshaft torsional vibration which became acute in several instances about a year ago. Much effort has been expended toward the improvement of existing instruments and the development of new instruments for measuring torsional vibration and this, on the whole, has been successful. In the meantime, one engine company has adopted a simple and effective vibration absorber which seems to eliminate torsional resonance of the crankshaft.

In the field of propellers, the most interesting development has been that of the constant-speed mechanism, whereby the blade angle of a controllable-pitch propeller is changed automatically to maintain a constant speed under all flying conditions. This arrangement has a number of advantages from the aerodynamic and power-plant viewpoints. One manufacturer has developed a brake for stopping the propeller in the event of engine failure on a multiengine airplane. The use of such a mechanism improves the performance and controllability obtainable with the engines which remain in operation. The National Advisory Committee for Aeronautics has attacked the problem of propeller noise (2), the work being confined, so far, to analysis of the noise from existing propellers. An interesting study of the relationship between engine output and propeller performance has been published (3).

The increasing number of controls requiring the attention of the pilot, and particularly the advent of the constant-speed propeller, has directed attention to the possibility of rendering certain controls automatic. Automatic controls for fuel-air ratio (4) and for oil temperature are already in service on some airplanes.

In the field of cooling, flaps on the cowl outlet of double-row air-cooled radial engines have been put into service quite generally (16). Considerable trouble was experienced at first due to the turbulence created by such flaps in the open position, but this has now largely been overcome. An important report on the baffling of finned cylinders (5) has been issued by the N.A.C.A. This organization has also continued its productive researches on the cooling and cowling of full-scale radial engines.

The long running periods between overhaul of certain European engines using blended oil (mineral oil with additions of animal or vegetable oil, or organic acid) have directed interest toward the possibility of using such oils in this country (6). Research to determine the possibilities and limitations of blended oils under American service conditions has already been started. The need for research on the effect of oil composition on the "gumming" of piston rings and on "sludge" formation has also been intensified by the higher outputs and operating temperatures, and work along this line has been undertaken by several laboratories (7).

An undercurrent of interest in the two-cycle engine, especially for use with the compression-ignition cycle, has been in evidence throughout the year. The N.A.C.A. has published the results of one research in this field (8) and it is understood that several manufacturers are working on large engines of this type. The development of several spark-ignition engines of 1000 hp or more has been continued, but so far none of these has reached the service stage.

It is interesting to note that the large engines under development, whether of the spark or compression-ignition type, are generally liquid-cooled and of nonradial form. This is probably due to the fact that the streamlining of modern airplanes has been developed to the point where the drag of the air-cooled radial engines is a large portion of the total drag. The next logical step in improving aerodynamic features may be that of placing the engines entirely within the structure, and using "skin"-type radiators. Now that most airplanes are metal covered, the skin-type radiator should not involve any great weight increase, or other serious technical difficulties.

The N.A.C.A. has continued its extensive researches in the field of the compression-ignition engine. Reference (9) gives the results of recent single-cylinder work of special interest. Reference (10) summarizes the work to date on spray characteristics from various nozzles and should be useful to designers of compression-ignition engines.

Research in the field of the mechanism of combustion, both for spray-ignition engines (11) (12) and for homogeneous gaseous mixtures (13) (14), has been continued with interesting results. In this connection, the measurements of temperature within a working cylinder, by Rassweiler and Withrow (15), deserve special mention.

[4] Prepared by C. Fayette Taylor, Professor of Automotive Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

[5] Numbers in parentheses refer to the Bibliography.

BIBLIOGRAPHY

1 "Aircraft Engine Performance With 100 Octane Fuel," by F. D. Klein, *Journal of the Aeronautical Sciences*, vol. 2, no. 2, March, 1935.

2 "Noise From Two-Blade Propellers," by E. Z. Stowell and A. G. Deming, National Advisory Committee for Aeronautics, Technical Report No. 526, 1935.

3 "Propeller Limitations on Aircraft Engine Design," by E. S. Taylor, *Journal of the Aeronautical Sciences*, vol. 2, no. 4, July, 1935, pp. 153–155.

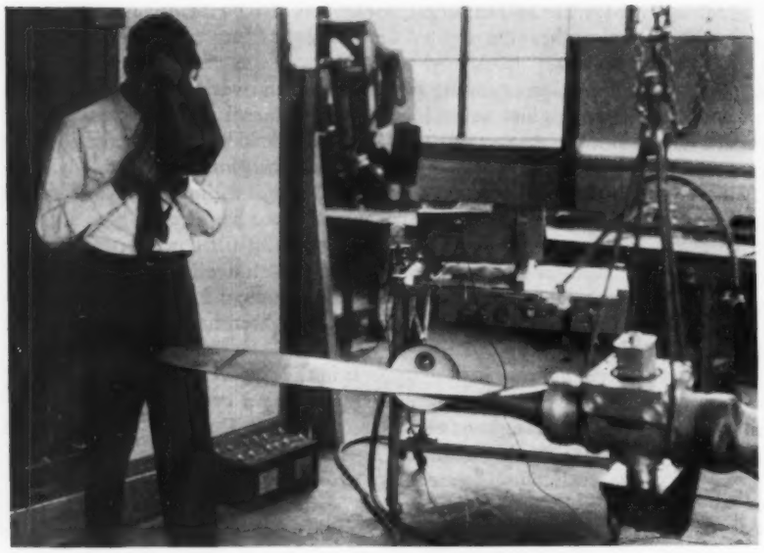
4 "An Automatic Power and Mixture Control for Aircraft Engines," by G. E. Beardsley, Jr., *S.A.E. Journal*, vol. 37, no. 2, August, 1935, pp. 301–306.

5 "The Effect of Baffles on the Temperature-Distribution and Heat-Transfer Coefficients of Finned Cylinders," by O. W. Schey and V. G. Rollin, National Advisory Committee for Aeronautics, Technical Report No. 511, 1934.

6 "Aircraft Engine Lubrication," by E. L. Bass, *Journal of the Aeronautical Sciences*, vol. 2, no. 4, July, 1935, pp. 171–174.

7 "The Influence of Engine Oils on Aircraft-Engine Performance," by S. D. Heron, *S.A.E. Journal*, vol. 36, no. 5, June, 1935, pp. 201–205.

8 "A Description and Test Results of a Spark-Ignition and a Compression-Ignition 2-Stroke-Cycle Engine," by J. A. Spanogle and E. G. Whitney, National Advisory Committee for Aeronautics, Technical Report No. 495, 1934, pp. 395–411.



TESTING PROPELLER VIBRATIONS—LINE OF DUST ACROSS BLADE SHOWS AREA OF WEAKNESS

9 "High-Speed Compression-Ignition Engine Performance; Three Types of Combustion Chamber," by E. G. Whitney, *S.A.E. Journal*, vol. 37, no. 3, September, 1935, pp. 328–341.

10 "A Comparison of Fuel Sprays From Several Types of Injection Nozzles," by D. W. Lee, National Advisory Committee for Aeronautics, Technical Report No. 520, 1935.

11 "Some Factors Affecting Combustion in an Internal-Combustion Engine," by A. M. Rothrock and M. Cohn, National Advisory Committee for Aeronautics, Technical Report No. 512, 1934.

12 "Some Effects of Injection Advance Angle, Engine-Jacket Temperature, and Speed on Combustion in a Compression-Ignition Engine," by A. M. Rothrock and C. D. Waldron, National Advisory Committee for Aeronautics, Technical Report No. 525, 1935.

13 "The Effect of Water Vapor on Flame Velocity in Equivalent CO-O_2 Mixtures," by E. F. Fiock and H. K. King, National Advisory Committee for Aeronautics, Technical Report No. 531, 1935.

14 "The Soap-Bubble Method of Studying the Combustion of Mixtures of CO and O_2," by E. F. Fiock and C. H. Roeder, National Advisory Committee for Aeronautics, Technical Report No. 532, 1935.

15 "Flame Temperatures Vary With Knock and Combustion-Chamber Position," by G. M. Rassweiler and L. Withrow, *S.A.E. Journal*, vol. 36, no. 4, April, 1935, pp. 125–135.

16 "Further Progress in Controlled Cooling of Radial Aircraft Engines," by J. M. Shoemaker, T. B. Rhines, and H. H. Sargent, Jr., *S.A.E. Journal*, vol. 37, no. 3, October, 1935, pp. 349–360.

MATÉRIEL DIVISION ACTIVITIES[6]

Procurement of aircraft is influenced by the rapidity of aircraft design evolution. There has been a steady advance in materials, in aerodynamic refinement, in engine power, and in propeller efficiency.

A modern airplane requires three to five years for development, commencing with design and construction of an experimental article; testing of engineering, performance, and specific military requirements; service testing for the purpose of obtaining its special tactical military value; and, finally, procurement in quantity for use in the tactical organizations of the Air Corps.

A consideration of experience and statistics leads to the unerring conclusion that the first airplane purchased from a completely new design has small hopes of being placed in production as received. Problems of arrangement, aerodynamics, strength, flying qualities, and performance are still so complicated in their interrelations, that it is difficult to calculate exactly the effect of each on the other.

[6] Prepared by A. W. Robins, Brigadier-General, Air Corps, U. S. Army, Chief of Matériel Division, Wright Field, Dayton, Ohio. Abridged.

AERODYNAMICS AND AIRCRAFT

In connection with the raising of specification requirements for all types of aircraft aerodynamic improvements were mandatory. Extensive wind-tunnel tests were conducted on model aircraft for the purpose of obtaining data on which to base performance specifications in future procurement. The coordination of calculation with flight-test results was furthered, especially in connection with controllable or automatic propellers. Field equipment for photographically measuring take-off and landing was developed in this connection.

1935 found the low-wing monoplane established as typical in military aircraft. The advantage of compactness, held by the biplane, is of no great importance for land operations, and the structural strength of the biplane is no longer preeminent in view of the recent developments in stressed-skin wing and fuselage construction.

During the calendar year of 1935, development was particularly demonstrated in the bombardment types. Outstanding were the Martin, Douglas, and Boeing airplanes submitted on procurement competition. The number was reduced to two by the crash of the Boeing bomber on October 30. This latter airplane represented an interesting step in bombardment design in respect to both performance and arrangement. Fortunately, a large amount of engineering as well as some flight-test data were obtained prior to the crash, so that the invested effort was not lost to military purposes.

The autogiro has been given serious military consideration, and a contract was let for one each of two types. These will receive study and testing to determine their tactical value. The evaluation of data on airplanes and designs submitted in competition during the year has absorbed a large percentage of the available time of the engineering personnel.

Considerable success has been met in eliminating from aircraft structures the causes of destructive vibration. The control of conditions governing flutter and vibration has become increasingly important as the speed and size of aircraft have mounted.

The use of leading-edge slots and auxiliary airfoils is

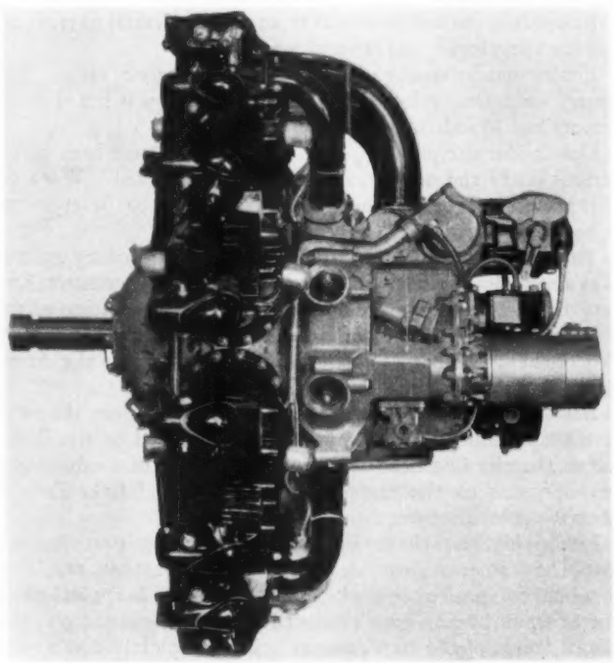
PROPELLER TEST RIG WITH PROPELLER MOUNTED READY FOR TESTING

STATIC TESTING OF AIRPLANE WING

definitely abandoned. The search for lower speeds and steeper angles in landing is being continued through the medium of different types of flaps which have become almost universal on military airplanes as a means of improving landing and take-off characteristics.

PROPELLERS

The propeller test rig, the largest plant of its kind in the world, continued to serve the Air Corps, the aircraft industry, and the Navy. With the improved methods used by the Air Corps for testing vibration qualities of propellers, important advances have been made to keep propeller design abreast of the increasing horsepowers of engines. Since it has been found that practically all the Air Corps propeller failures could be attributed to vibration, a vibration study has been included as part of the Army acceptance tests. A magnetic pick-up for mounting on the blade, for vibration-recording in flight, has been developed.



AUTOMATIC FUEL INJECTOR

STRUCTURAL DEVELOPMENT AND RESEARCH

The use of symmetrical airfoils and stable airfoils having very low and relatively constant moment coefficients has been encouraged and incorporated in all new designs as a measure of reducing the possibility of flutter due to aerodynamic instability at high speeds. This use also makes possible a saving of weight due to the smaller torsional moments to be handled by the wing structure.

The static-test laboratory continued its development of improved test methods. This laboratory, with its massive testing stands, its special light portable scaffolding, and its precise apparatus for measuring bending and torsional deflections, affords modern facilities for the sand loading of aircraft structures. Three complete airplanes were tested to destruction under loading conditions simulating the most severe flying and landing conditions likely to be encountered in service.

LIGHTER-THAN-AIR CRAFT

The TC-13 nonrigid dirigible airship has continued in service, with additional equipment, including a radio compass and an automatic directional pilot. One of the most important developments in this category is the construction of an observation-balloon envelope entirely from synthetic rubber. The balloon has been made ready for test.

An extremely light portable airship mooring mast of a type suitable for transport by airplane was tested.

POWER-PLANT DEVELOPMENT

Power-plant activities have been devoted to the development of aircraft engines of the radial, vee, and horizontal types, principally in the 800 to 1000-hp category. Considerable attention has also been given to the problems of introducing new models of service engines having higher power output and increased altitude ratings.

Marked progress has been made in the development of engine accessories, including fuel injectors and their application to engines; devices for the automatic control of carburetion (including fuel injection); magnetos; vacuum pumps for operating gyroscopic instruments and de-icer equipment; accessory drives; and lubricants for improving all-weather operation. New superchargers of increased size and weight and greater flexibility have been studied. Two turbosuperchargers have been procured for 600 to 1200 hp engines. Center air intake has been provided to obtain ramming effect, and arrangement has been made for varying the relation between the inlet and outlet of the compressor. Fuel of 100-octane

BIPLACE PURSUIT AIRPLANE

rating has been procured to the amount of 100,000 gal for test at Hamilton Field, a specification having been prepared for this fuel. Ice-forming tendencies of various fuels available commercially were investigated.

Synthetic rubber has been found satisfactory for refueling hose, and for fuel, oil, and water connections.

Work in aircraft armament for the year has included study and development of high-caliber aircraft guns utilizing explosive shells, electrically operated bomb racks, and mechanically operated flexible gun mounts. Studies leading toward the electrification of all bomb control and releasing mechanisms were instituted. Reduction of gun cameras from 35 to 25-mm film was made a project.

MATERIAL DEVELOPMENT

The Air Corps has adopted a policy requiring the use of Alclad for all combat planes designed with a noncorroding metal stressed skin, toward the end of obviating painting of the surfaces. Alclad metal offers the advantage also of giving satisfactory results in the tidewater stations where salt corrosion is troublesome.

A new aluminum-magnesium-chromium alloy has been studied, having resistance to tidewater corrosion, and having good welding characteristics. It has been recommended for cowling, fairing, and leading edges. Considerable progress has been made in the laboratory on spot welding of various aluminum alloys.

The Air Corps has been cooperating with other government bureaus on development of corrosion-resistant electrolytic surfaces for magnesium. At present the metal is used chiefly in cast form for engine parts.

The use of spot-welded stainless steel in aircraft construction, especially for aircraft operating in the vicinity of salt water, holds considerable promise. This method of welding has been approved for nonstressed parts such as cowling brackets, and reinforcing members.

In materials the transition from wood and fabric to metal for the structural parts of military aircraft has been pronounced during the past 15 years. All military airplanes procured during the current fiscal year were of all-metal construction in which aluminum alloys represented 80 to 85 per cent of the total weight of the structure. The use of the monocoque fuselage has drastically reduced steel requirements, while the air-cooled engine with its aluminum fuel and oil lines has almost eliminated the copper-base alloys.

EQUIPMENT

Progress has been made in the development and revision of navigating and engine instruments, aerial photography, parachutes, clothing, and electrical and miscellaneous equipment.

Pre-focused lamps have been specified for precluding faulty focusing in service. Revolving beacons will be equipped with these lamps in the 1000-watt, 115-volt size.

Four portable power plants have been studied, one consisting of a small engine and generator separate from the main power plant. These are for the purpose of supplying emergency power in lighter-than-air craft and amphibian airplanes.

An experimental light-weight direct-cranking electric starter has been tested, and will be installed in an airplane for eight months' service observation.

A new accelerometer and a sensitive altimeter have been tested, the latter under conditions of slight pressure change. This instrument reads 250-ft of altitude for one complete revolution of the pointer. A new navigation calculator for mechanically solving the astronomical triangle for celestial navigation has been developed, and ten articles ordered.

Engine-synchronizing devices have undergone tests. The Sperry automatic pilot tested on the YB-12A was found satisfactory and 30 additional units will be procured.

Devices for the prevention of ice formation have been given serious study and many tests have been conducted. Work on this project will be continued until completely satisfactory results are obtained.

The Army Air Corps instrument-flying and landing system was adopted as standard by the Bureau of Air Commerce, and sets of the equipment were ordered with the cooperation of the Matériel Division for installation in 36 commercial airports. Procurement has been initiated for installations at the Army fields.

Aerial mapping studies have continued throughout the year. A multiplex mapping machine has been loaned to the Pittsburgh District Engineer Office for the purpose of conducting a practical test on the mapping of the proposed Lake Erie to Ohio River canal route.

Interesting tests have been conducted using two five-lens mapping cameras suspended in a tandem mount resulting in a final composite print which is octagonal in shape and gives the effect of having been produced by a nine-lens camera, the center lenses of the two cameras being completely composite. Results of the practicability of this camera arrangement have not yet been determined.

DOUGLAS BOMBARDMENT AIRPLANE

Development has continued in electrically heated winter clothing.

A flash steam generator has been studied for heating engines located too high above the ground for application of ordinary engine heaters.

An acceleration machine for studying the physiological effects of increased accelerations on the human body has been built. It is a 20-ft fuselage, pivoted at the center for horizontal rotation, and it attains an acceleration 30 times the force of gravity.

One of the foremost accomplishments of the year was the successful prosecution of the stratosphere flight, on November 11, by Captains A. W. Stevens and Orvil A. Anderson. This flight was sponsored by the National Geographic Society and the U. S. Army Air Corps. Much of the testing of instruments and preparation work was performed at the Matériel Division. The results of the flight are too well known to need comment. These officers brought down the world's altitude record as well as most valuable scientific data and their associates cannot but enjoy with them the satisfaction of a job well done.

Although a year in which the multiplicity of work items has demanded the utmost of personnel, it is believed that the advance engineering foundations laid down have been basically sound and that the Matériel Division will advance along them to further accomplishments in 1936.

BUREAU OF AERONAUTICS, U. S. NAVY [7]

The chief concern of the Bureau of Aeronautics has been to maintain the aviation forces afloat in the highest state of readiness for war in accordance with the operating force plan. In order to maintain the proper condition of readiness for war it is necessary to provide aircraft and equipment which is modern, reliable, and superior to that used by foreign nations.

Funds provided for experimental purposes have been used to obtain the greatest possible improvement in airplanes, engines, instruments, radio, armament, materials, aerodynamics, carrier launching and arresting gear, and seaplane launching and recovery gear. Of particular interest are two torpedo-bomber landplanes and a new, long-range patrol plane, which are under procurement.

Funds provided for new and replacement aircraft have been used to procure aircraft of approved types, and in accordance with approved type complements, which embody the latest and most important developments in aeronautics. Ever-increasing high speeds have increased the take-off run and landing speed, both of the most extreme importance on board a carrier. The improvement in controllable-pitch propellers and the development of landing flaps have improved the landing and take-off characteristics of aircraft to the extent that carrier aircraft are now provided which compare favorably in performance with the landplanes which operate entirely from fields ashore.

AEROLOGY

In cooperation with the United States Weather Bureau, the Bureau of Aeronautics placed into effect a program of daily aerological flights for the purpose of obtaining aerological data up to high altitudes. These flights were made regularly at eight naval air stations. Flights of this nature were made also by planes attached to certain units of the fleet.

Plans were approved for the establishment of a Navy aerological station at Long Beach, Calif., in order to provide better weather service to naval aviation activities and to those units of the fleet that are operating in the area of San Pedro and San Diego.

The report of the Bering Sea Aerological Expedition was completed and distributed to the naval service.

An experienced aerological officer who had been given a special course of instruction at the Geophysical Institute, Bergen, Norway, was assigned to the staff of the Postgraduate School.

Together with the U. S. Army Air Corps and the Bureau of Air Commerce, the Bureau of Aeronautics has been cooperating with the Massachusetts Institute of Technology in the research on the dissipation of natural fog, which is being conducted at their research station at Round Hill, Massachusetts.

The Bureau of Aeronautics has been cooperating with the California Institute of Technology in a research investigation on gustiness and atmospheric diffusion. This research will be carried on at the Airship Institute at Akron, Ohio.

Aerological personnel and equipment were assigned to the 1935 Aleutian Island Survey Expedition.

At the request of the Commander-in-Chief, U. S. Fleet, an aerological unit was established on the fleet flagship and an experienced aerological officer was ordered to the staff of the Commander-in-Chief.

The following experimental or developmental work was undertaken in an effort to obtain improved aerological instru-

[7] Prepared by Rear-Admiral E. J. King, Chief of the Bureau of Aeronautics, U. S. Navy, Washington, D. C. Abridged.

ments and to develop new types to meet the special requirements of the Navy:

(*a*) Development of an improved aerograph for obtaining records of temperature, pressure, and humidity up to high altitudes.

(*b*) Design of suitable calibration equipment for calibrating naval aerological instruments.

(*c*) Development of a distant-recording hygrothermograph for shipboard use.

(*d*) Development of a precision aneroid barometer for shipboard use.

(*e*) Development of a portable air-speed meter as an aid in investigating the wing flow over the decks of airplane carriers and for use by expeditionary units.

(*f*) Development of an improved anemometer.

The policy of making use of the facilities of the National Bureau of Standards for testing and calibrating aerological instruments was continued with gratifying results. Data thus obtained were of value to the Bureau of Aeronautics and the manufacturers in designing instruments to give improved performance.

The recommendations of the Bureau of Aeronautics for the installation of the electrical wind-direction and velocity-indicating systems on all battleships and cruisers were approved by the Secretary of the Navy.

AIRSHIP DESIGN

The outstanding airship event during the year was the loss of the U.S.S. *Macon* through a forced landing at sea on Feb. 12, 1935. Investigation by a Court of Inquiry and careful analysis of all available data have thus far failed to establish convincingly all of the causes for the casualty and the various questions involved are being studied further.

Prior to her loss, gratifying improvement has been shown by the *Macon* in perfecting an organization and a doctrine of operations that was demonstrating increasing possibilities of usefulness to the fleet.

At the request of the Secretary of the Navy a special committee has been appointed by the Science Advisory Board "to review and analyze the past and present situation as to design and construction of airships (dirigibles) and to make recommendations as to their future design and construction."[8]

During the early part of the fiscal year, the General Board gave considerable attention to airship matters and in November recommended certain changes in general naval policy which were subsequently approved by the Secretary. The General Board also recommended the immediate building of a medium-sized dirigible and the construction of such nonrigid airships as are necessary for training and development of coastal patrol types. Recommendations similar in tenor were made by the Federal Aviation Commission.

All lighter-than-air activities have been concentrated at the Naval Air Station, Lakehurst, where several nonrigid airships are operated for training of personnel, both officers and enlisted men, and where various experimental development projects are being carried out, including an extensive experimental program centered around using the U.S.S. *Los Angeles* in a nonflight status. The Naval Air Station, Sunnyvale, Calif., has been curtailed, but is kept available for use to take care of airplane operations, relieving congestion at San Diego.

MAINTENANCE

During the fiscal year 1935 naval aviation overhaul bases overhauled 488 airplanes and 748 engines.

[8] See MECHANICAL ENGINEERING, March, 1936, pp. 142–143.

The number of flying hours for both airplanes and engines between overhauls has been substantially increased due to better overhaul work, improved design features, and improved operating maintenance.

The cost-accounting system of control of overhaul costs continued to show increased efficiency at overhaul bases for the fiscal year 1935.

The Bureau has established a new desk in the maintenance division having cognizance of machine tools and equipment. This function will, over a period of years, result in an economical and orderly replacement of worn-out and obsolete equipment and procurement of new equipment.

The stock-control system was modified to provide spare parts and aviation materials to operating units and overhaul bases as expeditiously as possible, consistent with existing procurement procedure and accounting regulations.

The 1935 maintenance tour of inspection of the leading Army, Navy, and civilian overhaul bases was completed and a conference was held in the Bureau following this tour at which various phases of the overhaul situation were discussed and recommendations for the coming year were made. Principal among these were the recommendations to continue to improve operating maintenance of aircraft to eliminate the large volume of minor work done at overhaul bases; to extend further the flying interval between overhauls within the limits of safety to redefine the cost-accounting system to prevent undesirable accounting practices from developing; to provide more effective means for the dissemination of information on overhaul methods between overhaul activities; to postpone large-scale attempts at standardization of methods until aircraft and aviation materials stabilize; and to exert further efforts to develop more effective stock control.

POWER PLANTS

The policy of providing the service with improved power plants has been continued by means of strenuous proof testing of service products, by 150-hour engine-endurance tests and 150-hour flight service tests of new-type airplanes, supplemented by special overspeed tests, and standardized tests of engine-propeller combinations. The scope of these tests has been increased to provide a more complete proof test of service conditions. The 150-hour engine test has likewise been applied periodically to engines overhauled by various overhaul activities to maintain the high standard of reliability of overhauled engines.

The completion, during the past year, of the development and proof testing of the dynamic damper and the release of this device for installation in service engines for the purpose of reduction or elimination of torsional vibration in crankshafts promises to be one of the most important advances in aviation power plants in recent years. Another outstanding advance has been the development of full pressure lubrication to cylinder valve gear, application of which to service-type engines is now in progress.

The two-row radial-type engine, now in its first year as a service model, has operated with marked success, justifying the expectations expressed during its development period.

As the result of developments in the experimental field, applications have been made to service power plants to improve installation features and to provide for better starting facilities under cold- or wet-weather conditions, together with a general improvement in the quality and method of application of fuels, oils, and lubricants, all of which should render service operations more efficient. Improvement has been made in the ability of engines to withstand the corrosive effects of salt spray to which naval airplanes are so generally subjected.

Corrosion, however, continues to remain an active problem for study.

EXPERIMENTS AND MISCELLANEOUS DEVELOPMENTS

The object of the experimental and development program is to improve the service suitability and increase the performance of service airplanes. The experimentation is of two general natures:

(*a*) That of immediate application.

(*b*) That of a long-range nature, the application of which if indicated will not be made in the present fiscal year. During the past year, the performance and effectiveness of service-type airplanes have been greatly increased, and experimental models have been brought out which indicate still further improvement. This development has taken place in all types of naval aircraft, carrier based, those attached to battleships and cruisers, and also those in patrol squadrons. Competitive designs have been examined and contracts awarded for those considered most promising. After the competing planes are built and flight tested, selection is made of the airplane which is considered to offer the most advantage and procurement is then initiated for service quantities. Increased performance has been the result of both increased power and more efficient design.

SHIP INSTALLATIONS

Continued progress has been made in the reliability of operation of aircraft aboard ship. Further improvement is under way in carrier arresting gear and catapults.

STRUCTURAL DEVELOPMENT

Great stress has been laid, during the past year, on determining the design conditions which naval-aircraft structures have to meet. This has generally revealed the necessity for increased structural strength in airplanes of high performance, and steps are being progressively taken to incorporate increased structural strength in high-performance aircraft. The analytical determination of structural strength is supplemented by a large volume of physical testing. In this work the facilities of the Bureau of Standards, the National Advisory Committee for Aeronautics, and the Naval Aircraft Factory are used to a great degree.

INSTRUMENTS

Continued progress has been made in the development of new types, and the improvement of existing types, of flight, engine, and navigational instruments. Extensive service tests of automatic pilots installed in various types of airplanes and in an airship have been conducted to determine the suitability of automatic pilots for naval needs.

The installation of modern instrument equipment purchased for approximately 25 per cent of airplanes in service under an allocation of National Industrial Recovery Act funds has been carried on during the past year.

MATERIALS AND ACCESSORIES

Aircraft materials and accessories have formed the subject of continuing research and development. The beneficial results of the Service have been a gradual but extensive and continuous improvement in quality of materials, increased resistance to corrosion, reduction in weight, reduction in hydrodynamic and aerodynamic drag of exposed parts, and in simplification of accessory design. An important phase of routine test work has been the testing of the products of manufacturers against established specifications and standards, to develop new and acceptable sources of supply.

SPECIFICATIONS AND STANDARDIZATION

The past year has been characterized by an increased volume of specification writing. Many items hitherto purchased proprietarily have been reduced to specification form, to be purchased on the open market, under established functional requirements. The general specifications for airplane design are being constantly revised in the light of experience, with particular emphasis on maintenance characteristics. Airplane-type specifications for contract purposes have increased in number. Army-Navy standardization has continued and the new specifications will be brought into agreement between the two services and made the subject of standardization.

AERODYNAMICS

Aerodynamic improvements during the past five years have resulted in a marked reduction in drag with a corresponding increase in performance. Further improvement appears possible when a practical application of "boundary-layer control" is available. This problem is being studied by the National Advisory Committee for Aeronautics at the request of the Bureau of Aeronautics.

Investigation of high-lift devices and methods of improving lateral control at low speeds continue with promising results. The Bureau has supplied the National Advisory Committee for Aeronautics for test in the full-sail wind tunnel and in flight a series of wings fitted with high-lift devices, such as the Zap and external flaps, and the Fowler and Cunningham-Hall wings. The completion of this series of tests will enable satisfactory comparison of the advantages and disadvantages of high-lift devices.

The problems of flying-boat hull design are being studied with a series of large-size models supplied by the Bureau for testing in N.A.C.A. model basin at Langley Field. The use of the model basin at the Washington Navy Yard is available to this Bureau for design studies, but the limited capacity is a severe handicap to rapid design progress. The construction of the new model basin with a high-speed section is necessary to meet present design requirements.

RADIO

During the past year the Bureau has been able to reduce by 50 per cent the number of types of aircraft radio equipment required by naval aircraft with the view of simplifying the supply of spare parts and the indoctrination of service personnel. Continued progress has been made in obtaining greater output for the same allowable weight in order to match the increased cruising radii of higher performance airplanes.

ELECTRICAL EQUIPMENT

Improvements have been made in generating, lighting, control, distribution, and testing equipment, as well as in methods of installation. Reduction in numbers of types of electrical equipment has been effected by continued standardization.

NAVY BUILDING PROGRAM AND NEW AIRCRAFT CONSTRUCTION

The Vinson-Trammell Treaty Navy Bill authorizes the procurement of naval aircraft in numbers commensurate with the strength of the Navy in surface ships. A tentative program of aircraft construction has been recommended which will provide approximately 1910 airplanes by 1940–1942. During the past year new airplanes have been added to the naval aeronautical organization in accordance with this program. Funds have been provided in the 1936 budget to provide the airplanes for the new carriers *Yorktown* and *Enterprise* and six new cruisers now building.

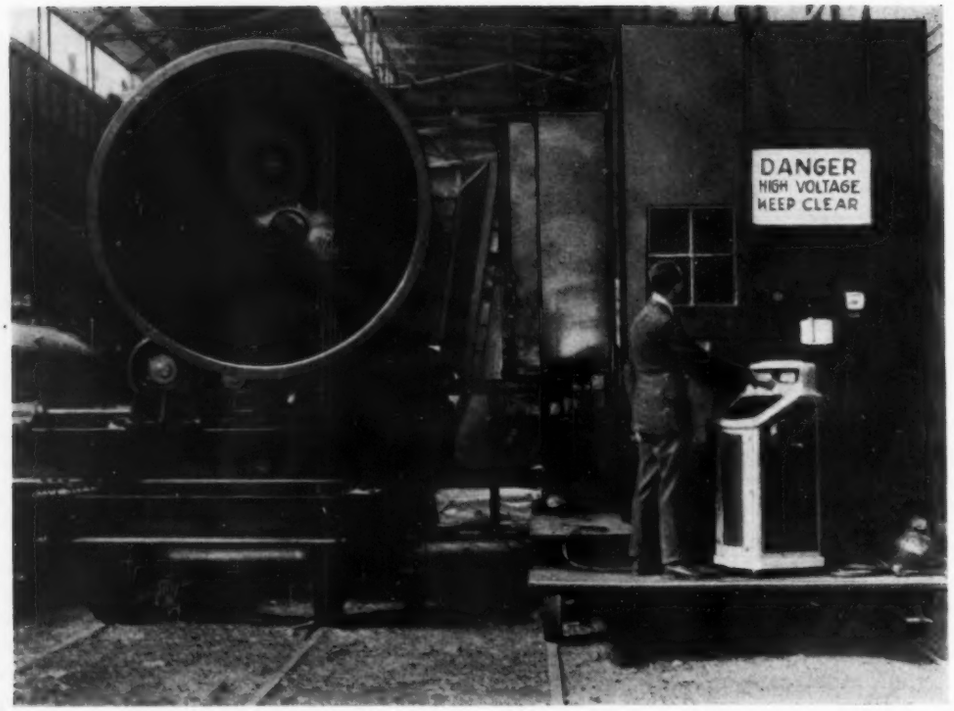


FIG. 1 X-RAY INSTALLATION FOR PRESSURE-VESSEL INSPECTION

Radiographic Inspection of WELDED REFINERY EQUIPMENT

By HERBERT R. ISENBURGER

ST. JOHN X-RAY SERVICE, INC., LONG ISLAND CITY, NEW YORK

RADIOGRAPHIC-inspection technique has been covered in two papers[1] previously presented to the A.S.M.E. by the author and further information may be found in a recent book[2] on industrial radiography. To these sources those who are not familiar with the basic theories of this method of nondestructive testing are referred. The present paper is confined to certain applications of the test method to welded oil-refining equipment.

For the most part, welded oil-refinery equipment consists of pressure vessels, fittings, and piping. Pressure vessels and fittings can be inspected in the fabricating shop before shipment, but most welding on pipe lines is being done in the field and must be inspected there. Even welded pressure vessels and fittings installed prior to inspection must be X-rayed in place. For shopwork a semiportable installation, Fig. 1, is most economical.

X-RAY INSTALLATION FOR INSPECTING PRESSURE-VESSEL WELDS

The stands for supporting the vessels during examination are special trucks, one of which is provided with two gear-driven rolls. The vessel can thus be rotated to any desired position or can be moved past the X-ray tube. A 200-kv, air-cooled Coolidge tube is mounted on an insulating framework within the large steel box seen near the right-hand face of the tank which is being examined. This box is lead-lined except for the opening through which the rays pass to the work. This opening is surrounded by an auxiliary lead shield which fills the space between the wall of the box and the wall of the tank, as shown in Fig. 2, and is flared out over the wall of the tank. The film holder is placed within the tank opposite the opening in the safety box, and is in turn covered with lead to absorb both direct and scattered X rays.

The safety box is mounted on trunnions on a telescoping frame so that it can be tilted forward and back, or moved nearer or further from the tank at will by means of two small hand-

[1] "Radiographic Inspection of Metals," by Herbert R. Isenburger, MECHANICAL ENGINEERING, vol. 53, 1931, pp. 729–735, and *Boiler Maker*, vol. 31, 1931, pp. 258–263.

"Recent Progress in X-Ray Inspection of Welds," by Herbert R. Isenburger, *Steel*, vol. 92, no. 23, 1933, pp. 29–32.

[2] "Industrial Radiography," by Ancel St. John and Herbert R. Isenburger, John Wiley & Sons, Inc., New York, 1934.

Contributed by the Petroleum Division and presented at the Semi-Annual Meeting, Dallas, Texas, June 15–20, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

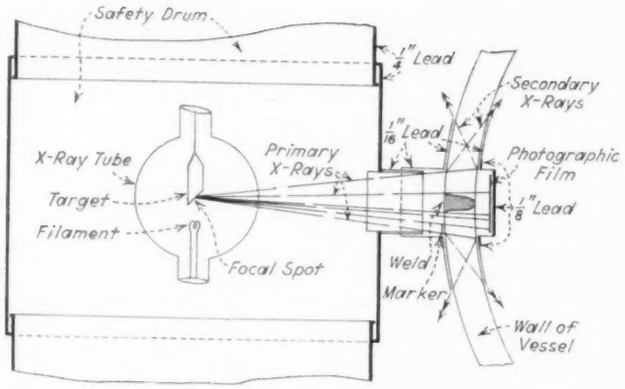


FIG. 2 EXPOSURE ARRANGEMENT FOR WELD INSPECTION

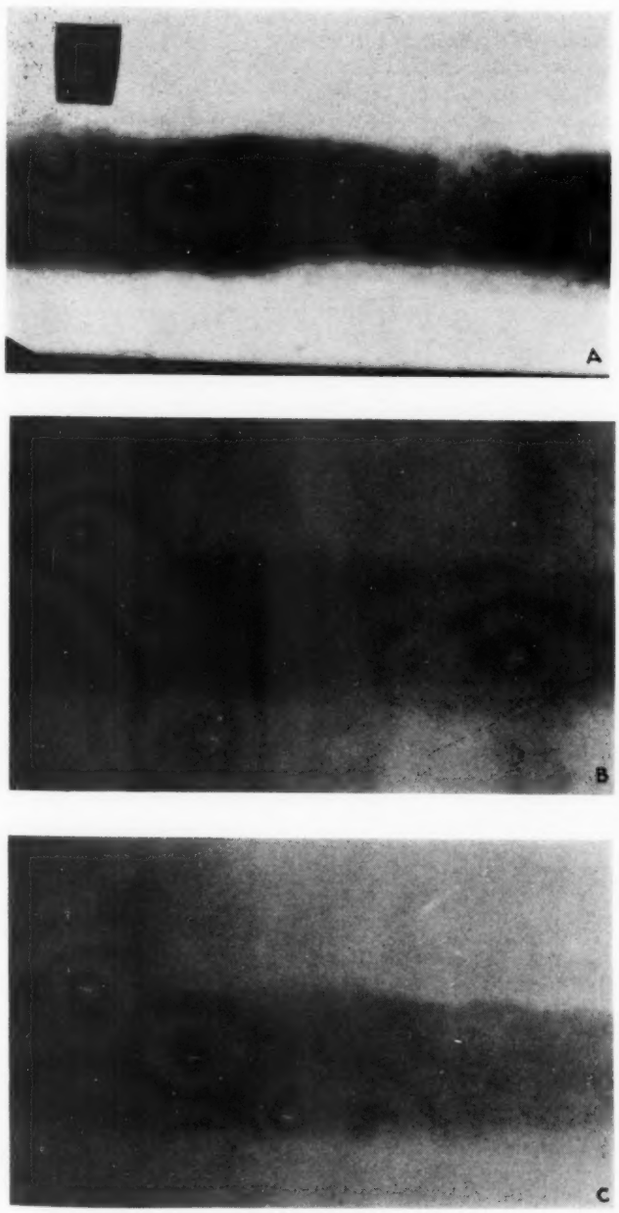


FIG. 3 RADIOGRAPHS OF THE SAME WELD
(*A* = exograph, *B* and *C* = gammagraphs.)

wheels. Together with its telescoping shields the safety box can be withdrawn completely into the far end of the sheet-steel housing which encloses the power plant. This housing is thoroughly grounded so that it is impossible for persons or equipment to come into contact with any high-voltage conductor. The entire equipment is mounted on a car which can be propelled in either direction along its track at slow speed.

EQUIPMENT FOR THICK WELDS

For wall thicknesses greater than 3 in. of steel, more powerful X-ray apparatus is required and special filters have been developed to absorb secondary radiation. On account of this so-called "Compton effect," X-ray machines between approximately 250 and 550 kv are of little value. It seems that we can overcome this scattering effect with voltages above 600 kv. At the present time we have no means of filtering all scattered radiation effectively.

On greater thicknesses of metal gamma rays can be used satisfactorily. They are specially helpful in field work where

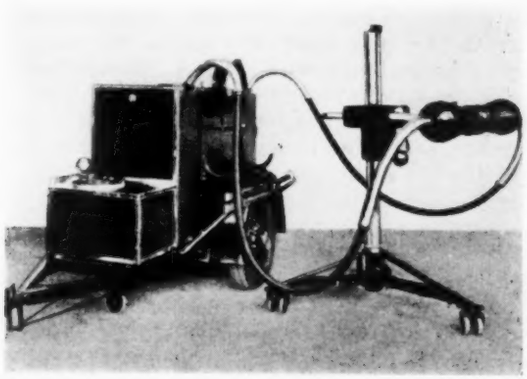


FIG. 4 PORTABLE X-RAY UNIT

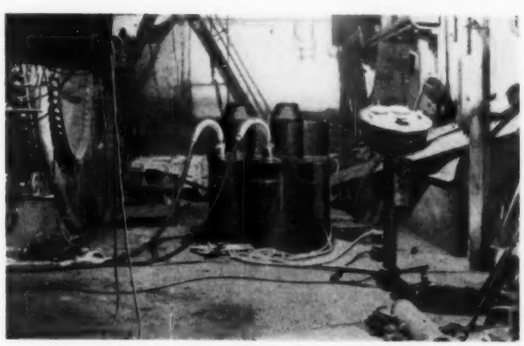


FIG. 5 X-RAY APPARATUS SET UP IN A BOILER HOUSE (SEIFERT)

circumferential seams should be examined. Due to their very short wave lengths, however, they are of but little value on steel less than 2 in. thick. In an attempt to prove their usefulness a fusion weld in steel plate $^3/_4$ in. thick was radiographed with three different techniques, as reproduced in Fig. 3. Exposure *A* was made with X rays at a voltage that gave a good picture in one minute. *B* is a gammagraph with 335 mg of radium exposed for 20 min. *C* is a gammagraph with 10 mg of radium exposed for 660 min, or 11 hr, giving substantially the same total exposure as *B*. Because of the smaller source, the definition in *C* is better than that in *B*, but the contrast is poor in both gammagraphs which do not disclose the in-

side conditions throughout the weld as depicted in the exograph *A*.

The influence of scattering upon the radiographs is much less for gamma rays than for X rays. In fact, it can usually be neglected entirely, and the precautions against scattered radiation necessary with X rays can be dispensed with when gamma rays are used. However, it is not possible to dispense with provision for the protection of persons against exposure to the gamma rays, either during the long period when the radioactive material is being used or during the comparatively short periods when it is handled at close range while being placed in position and removed.

PORTABLE X-RAY EQUIPMENT

It may be that with some special technique, as yet undeveloped, we shall be able to obtain suitable results with gamma rays through any thickness of metal. Until then, however, we must use X-ray equipment for the inspection of field welds. This fact has been recognized in Europe for quite some time, and special portable X-ray units have been developed and are in use for airplane and ship inspection, and the examination of welded bridge and building structures. One machine which seems to be specially fitted for the field inspection of oil-refinery equipment is illustrated in Fig. 4. Mounted on a small trailer, it can be carried readily from place to place. It is completely shock- and X ray-proof, thus making its performance perfectly safe. Two inches of steel can be penetrated with this machine in a one-minute exposure. Due to certain design characteristics of the equipment, the exposure times are unusually short for the relative metal thicknesses and voltages used, as can be seen from the curves in Fig. 6.

Another portable X-ray equipment set up in a boiler house is shown in Fig. 5. The capacity of this unit including the X-ray-proof tube is 300 kv. The tube is mounted inside the boiler. The shockproof cables are some 70 ft long in this case. They have to be made very carefully to withstand the unfavorable operating conditions usually prevailing in a refinery or the weather conditions in the field.

Besides the inspection of welded seams in bubble towers, cracking stills, equalizers, and other pressure vessels, welded pipe is another important type of oil-industry equipment which should be X-rayed. Small-diameter pipe, like thermocouple tubing, can be examined in the shop. In fact, the author developed a technique whereby the entire circumference can be recorded in three exposures on one single film. For larger pipe, and especially in field work, different methods must be employed. Whenever possible, the film should be placed on the inside of the pipe. Where this is not possible, the film can be placed behind the pipe, and two exposures are required on one

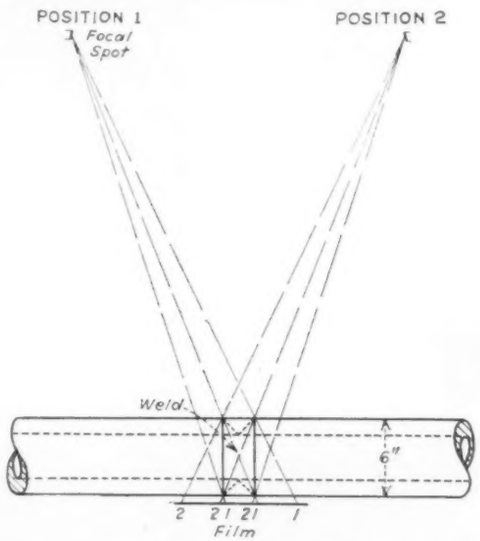


FIG. 7 OFFSET METHOD FOR WELDED-PIPE INSPECTION

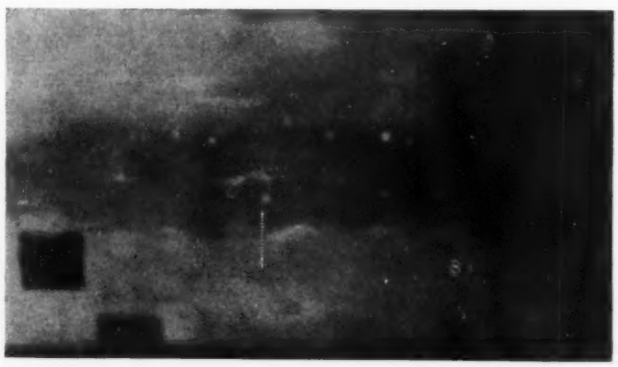


FIG. 8 DOUBLE-EXPOSURE EXOGRAPH OF A WELDED SEAM

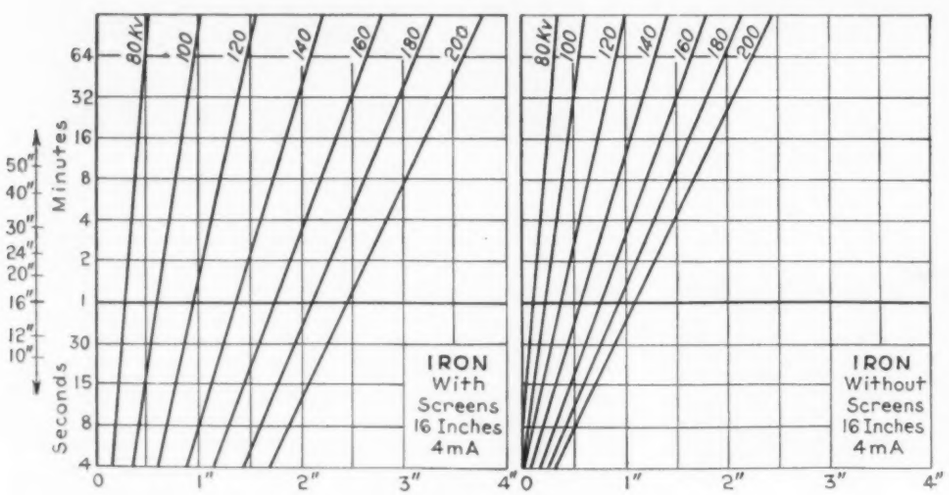


FIG. 6 EXPOSURE CURVES WITH UNIT OF FIG. 4

single film. Between the exposures the position of the X-ray tube must be changed as indicated in Fig. 7. In each position the central beam is approximately parallel to one scarf of the weld. Thus there results a double image which requires expert interpretation. Naturally, defects contained in the section of the pipe closer to the tube will appear somewhat distorted in the negative and give exaggerated effects. The result is similar to that obtained by a double exposure. Fig. 8, used for determining from which side a defective weld should be repaired.

At the installation shown

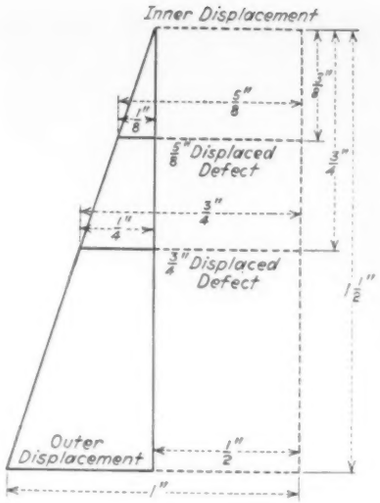


FIG. 9 CALCULATING THE LOCATION OF A DEFECT INSIDE A WELD

in Fig. 1 the frame supporting the X-ray tube in the safety box can be displaced about $2^1/_2$ in. diagonally upward to the right or the same distance downward to the left. The square marker in Fig. 8 is on the outer surface, and the long marker is a lead strip placed on the inner surface of a tank. This was a double-V weld, and the exograph shows that the poor fusion represented by the light streaks is part way down one scarf of the inner V. The depth was localized to about $^1/_{32}$ in. so that the overlying metal could be chipped out rapidly until this depth was approached. Then the remaining metal was chipped more slowly until the defect was disclosed, when it was examined, repaired, and the region reexographed.

From the double-exposure negative the distance between a defect and the film can be calculated. In Fig. 8 careful measurement shows that the displacement on the outside is just 1 in., whereas the inside marker is displaced only $^1/_2$ in. A comparison of the relative displacements of the various defects in the weld metal shows them all to be between $^3/_4$ and $^5/_8$ in., indicating that the defects occur in the inner half of the weld.

LOCATING DEFECTS IN WELDS

It is now a simple matter to calculate how far from the inner surface a $^5/_8$-in. displaced defect lies. The thickness of this particular weld is $1^1/_2$ in. Hence, the various displacements may be represented by a right triangle as in Fig. 9, with an altitude of $1^1/_2$ in. and a base of $^1/_2$ in. (the difference between the outer and inner displacements). Then by simple proportion the altitude of a similar triangle, with a base equal to the increased displacement of the defect over that of the inner marker, can be calculated. For the $^5/_8$-in. displaced defect this is $^3/_8$ in., meaning that the defect is $^3/_8$ in. from the inner surface of the vessel. Similarly, a defect of $^3/_4$-in. displacement lies at the median line of the weld.

When X-raying thick plate stock it is advisable to machine off all excess weld metal. A porous weld in $2^1/_2$-in. plate is shown in Fig. 10. Fig. 11 depicts the difference which may exist between the exograph of weld with beads and the same weld after removal of the beads. When the beads are present the changes in transparency are well defined between the dark central band where the X rays have traversed both beads as well as the underlying parts of the weld and plate, the intermediate band where the rays have traversed only one bead, and

FIG. 10 (ABOVE) EXOGRAPH OF POROUS WELD IN $2^1/_2$-IN. PLATE STOCK

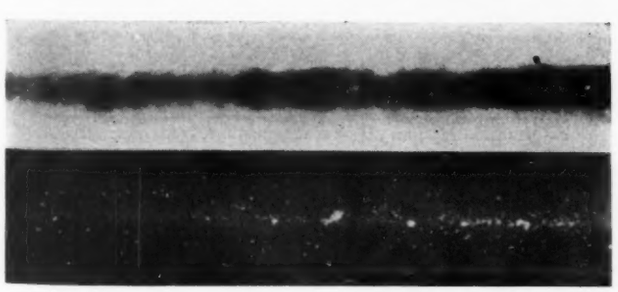


FIG. 11 DEFECTIVE WELD WITH AND WITHOUT EXCESS WELD METAL

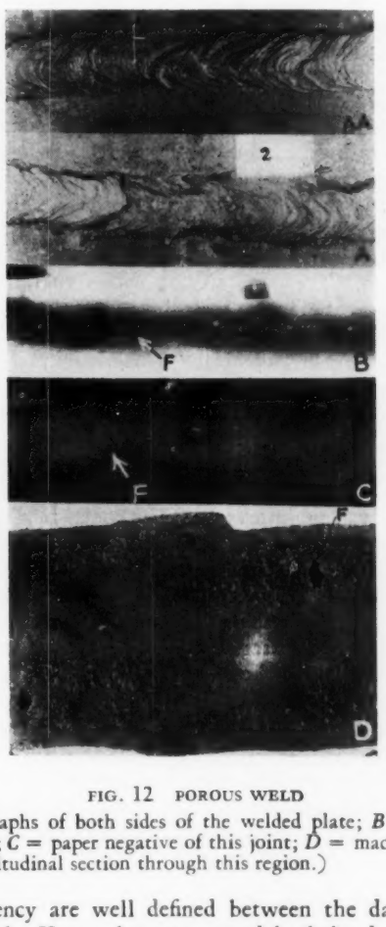


FIG. 12 POROUS WELD

(*AA* and *A* = photographs of both sides of the welded plate; *B* = positive print from film; *C* = paper negative of this joint; *D* = macrograph of longitudinal section through this region.)

FIG. 14 HAIR CRACKS IN SEAMLESS PIPE

the underlying metal, and the outer regions where the rays have traversed nothing but the plate. When the beads have been milled off the welded region has the same film density as the plate itself. As far as the defects are concerned, they appear to be more numerous in this case when the beads are removed, since they are of an order less than 2 per cent of the total plate thickness and were thus covered up by the excess metal. In some cases, especially in single-V welds, it is advisable to make two exposures parallel to each scarf.

Fig. 12 presents photographs of a double-V weld in $^3/_4$-in. plate stock, together with the exograph in this region and a section through the cavity marked *F* magnified three diameters. An abrupt offset in one bead is seen clearly in the exograph and appears in the section. At this place the electrodes had been changed. The junction of the new bead with the old is plainly indicated by the band of refined metal. Another specimen by the same welder using a different technique gave the result depicted in Fig. 13. In addition to considerable porosity as in the other specimen this has an almost continuous line of cavities along the center of the weld. This, by the way, is more obvious in the paper negative than in the print from the film. The cross section shows that this is due to complete absence of fusion at the bottom of the two V's.

Fig. 14 represents part of a crack discovered in seamless pipe having a $^5/_8$-in. wall. These hair cracks are a great deal more extensive than would be suspected from surface indications observed after the piece had been removed for study. Good results have thus been obtained on detecting cracks around rivet holes in boiler plate. This would all seem to be contrary to the fact that it is difficult to detect cavities much less than 2 per cent of the thickness. The contradiction disappears, however, when we realize that a crack in which the two faces are separated by 0.001 in. would present an aspect more than 0.01 in. deep to X rays making an angle of 5 deg with the crack, or an aspect more than 0.05 in. deep to those at less than 1 deg. There is a reasonable chance that for some portion of the transverse fissure the X rays will be passing close to the "plane" of the crack and will produce a clear record. Since lack of fusion is the most serious defect in a weld and may be nothing but a very fine crack, it has been suggested the rays be directed parallel to the scarfs in an attempt to pass through the plane of the defect which otherwise may not be detected.

EXPERT INTERPRETATION NECESSARY

In field inspection more so than in shopwork where the technique can be better controlled, utmost care must be taken to obtain the correct interpretation of the results. This requires expert knowledge which can only be acquired by long experience. With the proper equipment and necessary photographic materials, a man familiar with metal radiography should not have any difficulty in doing a good job on field inspection of oil-refinery equipment. The tools are available to the refineries. It is now up to them to take advantage of this unique method of nondestructive testing of materials before and during service.

The value of this inspection tool has been established unquestionably. Manufacturers of welded oil-refining equip-

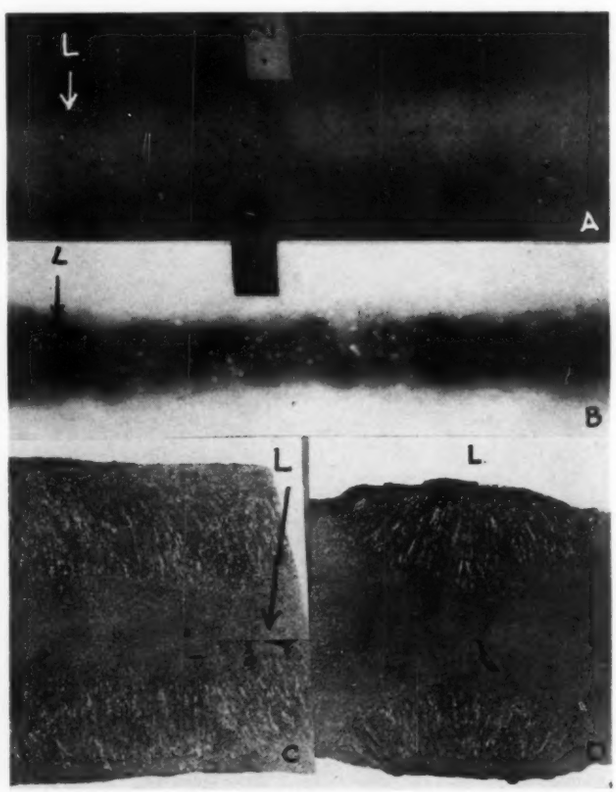


FIG. 13 LACK OF FUSION AT THE ROOTS OF A DOUBLE-V WELD (*A* = paper negative; *B* = print from the same film; *C* = macrograph of longitudinal section; *D* = macrograph of transverse section.)

ment who were originally opposed to X-ray inspection of their products are now grateful for the service radiography furnishes to them. As one manufacturer stated recently, his shop had to reject about 25 per cent of welded seams when he first installed X-ray equipment. Two years later the average of rejections dropped to 5 per cent. The psychological effect, alone, upon the welder is held responsible for this improvement.

THE FEDERAL SOCIAL-SECURITY PLAN

By JOHN SHUTE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PERHAPS no New Deal legislation is more far-reaching in effects than the Social Security Act, and yet, because its immediate results are not spectacular, it has received relatively little attention. It is fortunate, therefore, that Prof. Paul H. Douglas, a pioneer in the fight for social insurance, has chosen to explain and comment upon the act.[1] Although disagreeing with its methods—he believes that government contributions are essential to the success of social-security plans—Professor Douglas has written a book which is at once fair, authoritative, and complete.

Social insurance of various types has been in effect in some European countries for more than 50 years, and yet our attempts were hailed as "revolutionary" and "utopian." This lag in social consciousness may be accounted for to some extent by the nonmilitant, opportunist character of the American labor movement, which refused to recognize the need for social insurance until the passage of federal legislation seemed imminent. Probably the most serious deterrent was in the nature of our governmental machinery. Since all power not specifically delegated to the federal government by the constitution belongs to the states, we are, as a nation, reduced to correcting the social evils of 1787. While it is true that many states had provisions for some kind of social insurance prior to the enactment of the national social-security law, these state plans were generally inadequate and conflicting.

HISTORY OF THE ACT

In a very readable style Professor Douglas traces the immediate history of the social-security movement and explains the forces which shaped the legislation into its present form. The act is essentially the work of the Committee on Economic Security created by the President in June, 1934. After studying the problem for six months the committee made its recommendations, which were incorporated into the Wagner-Lewis bill and introduced into the Congress in January, 1935.

It is rather an ironical commentary on our national temper that the Brobdingnagian economics of Dr. Townsend should have more vital effect in the realization of social-insurance plans than the work of such pioneers as Abraham Epstein, I. M. Rubinow, and Paul Douglas. For it was the threats of the Townsendites and the left-wing advocates of the Lundeen bill which sent shivers of terror into the hearts of the reactionaries and caused them to accept the Administration bill as the least distressing of several evils. With some changes the bill was passed by Congress and signed by the President on August 18, 1935.

Social-security legislation may be divided into three major provisions for groups subject to special economic hazards. These are: (1) Unemployment insurance; (2) provision for indigent old age; (3) grants for welfare purposes, (*a*) security for children, (*b*) aid to the blind, (*c*) extensions of the public-health service, and (*d*) provision for vocational rehabilitation.

[1] "Social Security in the United States," by Paul H. Douglas, McGraw-Hill Book Company, New York, 1936.

One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The first two provisions are most important and are so far-reaching in scope and so varied in implication that their ultimate effects, at the present, can be only vaguely surmised. The greater part of Professor Douglas' book is devoted to an explanation of these provisions, and since an intelligent discussion of the probable effects of the legislation requires a clear understanding of these, it is perhaps well to summarize briefly their more important features.

UNEMPLOYMENT INSURANCE

The unemployment-insurance provisions of the act do not actually set up machinery for the realization of this end, but instead, by a tax offset scheme, the states are forced into providing such insurance. A payroll tax on wages and salaries, increasing from 1 per cent in 1936 to a maximum of 3 per cent in 1938, is imposed upon all but a few large excluded groups by the federal government. Payments of state taxes for the same purpose may be credited up to 90 per cent against the federal tax. Thus if a state does not enact acceptable legislation, its industries are penalized by a tax from which the state receives no benefits. To be acceptable the state legislation must meet certain conditions, intended generally to protect organized labor, and to safeguard the funds collected from political machinations. All monies collected must be turned over to the United States Treasury to become a part of the "Unemployment Trust Fund." The money is invested as a single fund, but the resources of the states are not pooled, separate accounts being kept for each state. The fund can be invested only in United States securities, or obligations guaranteed both as to principal and interest by the United States. Large groups of wage-earners are excluded from the plan, the more important being (*a*) agricultural workers, (*b*) employees of the federal, state, and local governments, (*c*) workers in establishments employing less than eight, (*d*) employees of organizations not operating for profit. The cost of administration is paid entirely by the federal government. However, it is believed that the 10 per cent against which state taxes cannot be credited will more than amply provide for administration costs.

As expected, there is much variation in the provisions of the state laws. Benefit payments average 50 per cent of normal wages, and these payments are begun after an average waiting period of three weeks and continue for about 16 weeks. Many states require contributions from employees, while in Washington, D. C., the government supplies part of the fund.

OLD-AGE PENSIONS

Late in 1934 Dr. Townsend came out of the West with a double-barreled scheme to end our economic woes and provide old-age pensions. Naturally, for a nation given to economic anodynes, the benign Californian's appeal was irresistible, affecting as it did both our emotional and pecuniary sensibilities. As already pointed out, the Townsend movement served the administration well, for it not only focused public attention upon the problem of indigent old age, but, of more practical import, it forced the more recalcitrant representatives of rugged individualism into line.

The social-security legislation offers two kinds of protection for the aged: (*a*) A state old-age pension system, financed by

matched federal grants, and (*b*) a national system of old-age annuities. Under the first plan the federal government agrees to provide one half the cost of old-age pensions up to $30 per month on condition that the state law meets certain simple conditions as to benefits, eligibility, etc. For the fiscal year 1935–1936 the national government has allotted 49 million dollars for this purpose. This old-age pension system is not in itself satisfactory, however. First of all, it is too expensive. Actuaries have estimated that by 1965 the total annual expenditures would be in excess of two billion dollars. Secondly, it involves a means test, entirely incompatible with any broad conception of social justice. Chiefly because of these reasons a supplementary provision, the old-age annuity plan, was enacted. It is estimated that by 1980 this plan will reduce old-age-pension expenditures by 60 per cent.

FUND TO BE RAISED AND ITS EFFECTS

Under the old-age insurance or annuity plan, taxes are levied upon employers' payrolls and upon the wages of the employee. For the purposes of this section, wages are defined as the first $3000 of remuneration. Tax rates and excluded groups are the same as in the unemployment insurance plan, the tax reaching a maximum of 3 per cent (from employer and employee, total 6 per cent) in 1949 instead of in 1938, as in the unemployment plan. Careful records of earnings must be kept, for the annuities are calculated upon this basis. To receive benefits upon reaching the age of 65, an individual must have made payments on wages totaling $2000 over a period of at least five years, and must give up remunerative employment.

Much speculation has been given to the possible results and uses of the tremendous reserve fund created by the act. Since the fund must be invested in government securities, or government-guaranteed obligations, the public debt may be removed entirely from private hands. As a result, income-tax returns should increase greatly because of the disappearance of tax-free securities from the open market. Even at the present high figures the national debt is less than 34 billion dollars (higher if certain government-guaranteed obligations are included). This gives some substance to the belief that the fund may act as an incentive for increased governmental expenditures.

Professor Douglas explains how the fund might be used in attempting to control the business cycle. By selling special bonds to the trust fund the government can become the creditor of the business system to the extent that payroll taxes are paid. Checks drawn on the banking system are turned over to the government and this reduces the deposits (reserves) of the member banks. The member banks may either restore their reserves by rediscounting or by reducing their loans. By raising the rediscount rate the banks can be forced into the latter course. By the same device it is possible for the government to stimulate credit expansion.

The record of the Federal Reserve System in using similar methods is not an impressive one. Although it is possible to slow down credit expansion, the reverse process is extremely difficult. Credit costs are such a small part of total costs that even in periods of depression great declines in interest rates are not sufficient to enable the business man to see the possibilities of profits. However, as Professor Douglas points out, the Social Security Act will help to soften the jolts of the business cycle in an entirely different way—by maintaining the purchasing power of the unemployed.

MUCH OF COST OF PLAN FALLS ON LABOR

A large part of the cost of the plan falls upon labor. Estimates of the proportion of the total burden to be borne by the wage-earner vary with the political position of the estimator. An undisputed one half of the tax for old-age annuities falls directly upon the employee. As consumers, the same group will absorb an additional share in the form of higher prices, and, by wage cuts and failure to advance wages, will assume another part of the total costs. At once the question is raised —If the income of a group is so low that its members are unable to protect themselves against economic hazards, how can you provide protection by taxing that income?

With existing income, such protection can only be afforded by a decline in the present standard of living. The process of saving, however, sets forces into action which tend to raise wages. We are attempting compulsory saving on a scale perhaps hitherto only approached by Soviet Russia during the first five-year plan. . By 1980 reserves of about 45 billion dollars will be built up by the old-age annuity plan alone, and more than one half of this capital will be created by the savings of a group who otherwise would not save. As a result, in addition to the ordinary increments to the national wealth, these new savings will probably swell the total much beyond the normal amount. With the deceleration of population growth, and this extraordinary increase in national capital, wage increases are inevitable, for wages are determined by the relative scarcity of capital and labor.

It may be expected, however, that these wage increases, although inevitable, will come slowly, and will be bitterly contested, for payroll taxes tend to place the just employer in an unfavorable competitive position with the employer of sweated labor. For the same reason existing geographical wage differentials will probably be accentuated.

A tax on payrolls is a tax upon the use of labor and thus becomes a kind of negative premium upon the use of labor-saving machinery. Of two manufacturers in the same industry, the one who uses the least labor, everything else being equal, is in a better competitive position now than before the enactment of the social-security legislation. We may expect, then, an acceleration of technical progress, and with this the accompanying problem of technological unemployment. Again, however, certain new compensatory forces will begin to operate. One of the chief instruments in the operation of the social security plan are the public employment bureaus. Not only will the scope of these agencies be greatly broadened, but more complete and accurate statistics of unemployment will be available. The centralization of the information will make for greater mobility of labor which has been the most difficult aspect of technological unemployment.

CONSTITUTIONALITY

In view of the vagaries of the Supreme Court, a discussion of the constitutionality of the act becomes a matter of speculation rather than logic. The grant-in-aid principle employed in the old-age pension and in the "grants for welfare purposes" is a much used device and these provisions seem most secure in event of a constitutionality test.

Tax offset schemes have also considerable precedent and have successfully passed the scrutiny of the court on several occasions —notably in the Florida vs. Mellon case, involving the federal estate tax. This is the regulatory method used in the unemployment section, so there is then good reason to believe this measure will also survive a court test.

It is the old-age annuity plan which seems least able to run the constitutionality gamut. This section, it will be recalled, involves an outright national system and as such may be considered as a usurpation of state rights. However, the legislation must face a far more critical test than that of the Supreme Court, and that is the test of effectiveness in operation—of this, only the experience of the future can decide.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The Breguet Gyroplane

THE Bréguet gyroplane is an improved helicopter in which the rotating blades, instead of the traditional propeller, furnish the forward propulsion. As these blades are mounted on universal joints they can also be used to insure directional and lateral control. The air pressures active on them depend at each instant on the relative speed of the blades and on the incidence at which the latter are adjusted. T ese elements vary during each revolution of the blade, the speed of rotation being added at each half turn to the forward speed at which the gyroplane is moving. Unless precautions were taken this fact would cause loss of stability but Bréguet has overcome this difficulty by attaching the rotor blades to their central hubs by means of universal joints mounted on two orthogonal axes. Each blade is therefore free to adjust itself during each revolution and can rise or fall independently. A high efficiency is claimed for this construction.

Altogether there are two rotors, both engine-driven, mounted on a pylon, one above the other, and turning in opposite directions. The unit has been constructed, but apparently has not been regularly flown. (*Flight*, vol. 28, no. 1408, Dec. 19, 1935, supplementary section, pp. c-d, 3 figs., cf. *La Technique Moderne*, vol. 28, no. 5, March 1, 1936, pp. 149–151, 4 figs.)

AIR MACHINERY

Voith Hydraulically Operated Rotary Air Compressor

THE principle underlying the design is that of compressing the air by pistons of water, the object being to deliver the air in a cold state and without contamination by either oil or dust. The machine consists of a cylinder *a*, in which a multiarmed rotor *b* revolves round a hollow shaft placed eccentrically to the cylinder. The problem of making contact between the rotor arms and the cylinder has been solved by hinged tips to the arms, which are kept against the cylinder wall by centrifugal action, and are therefore self-adjusting as regards wear. The several compartments of the rotor are, of course, cut off from one another, and all have a port in the boss. The hollow shaft is formed with two passages communicating with the outside by ports. The water content of the compartments when the compressor is at work is held to the outside by centrifugal force, and is the same amount in each compartment. This does not, at first sight, appear to be the case, but a study of the drawing will show that the volume between the lowest pair of arms and that between the highest pair differs considerably. The water is thus forced toward the boss as the compartment travels around from the top to the bottom, and the air space correspondingly decreases from a maximum to practically zero.

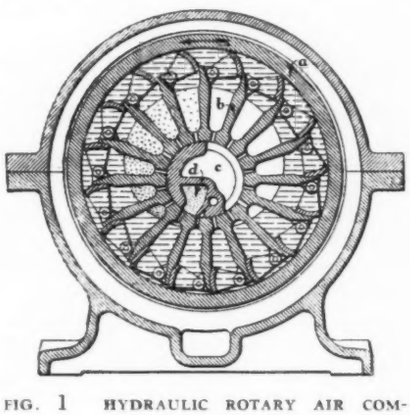


FIG. 1 HYDRAULIC ROTARY AIR COMPRESSOR

The air enters at *c*, and, following the compartments around in a counterclockwise direction from the bottom to the top, it will be seen that the volume of the compartments increases. Air is thus drawn in. When the volume begins to decrease the air inlet is cut off by the closing of the ports in the bottom of the compartments. Following the rotation from the top to the bottom, it will be seen that the volume progressively decreases, thus compressing the air content. At maximum compression the compartment port is opened to *d*, which is the discharge passage. The small port near *d* is for the purpose of filling the compartments initially with water, and of making good any losses. Any water carried in the compressed air is removed by a separator, an operation stated to be carried out effectively so that the compressed air is quite dry. As the water absorbs the heat generated in compression, the air is also cool. The water entraps any dust carried in the air and serves for lubrication, no oil being used in the compressor itself. It is stated that the compressor will give deliveries up to a pressure of 114 lb per sq in. (The Leipzig Fair, *Engineering*, vol. 141, no. 3665, Apr. 10, 1936, p. 389 and illustration on p. 390)

ELECTRICAL ENGINEERING

The General Transformer

THE apparatus described is essentially a stationary general transformer for alternating or direct current. Alternating-current power is received into a subdivided shell-type transformer, changed in desired ratio as to voltage and current, and through an included system of reed-mounted vibratory contacts, commutated to direct current for delivery. There is no mechanical rotation and no movement except processional vibration of numerous commutative elements tuned to 60, 50, and 25 cycles.

The commutative contactors are made up of metal contacts mounted upon tuned vibratory supports which, in turn, are driven by electromagnetic actuators excited by the transformer voltage, primary or secondary. Thus the working elements each following its own harmonic order and all tuned to the electric frequency, are more rigidly united in faithful cooperation than even the instruments of a fine orchestra. The mechanics of vibrating systems, especially the simpler forms and those intended to vibrate, is accurately determinate as may be cited in a classic text. Application of the vibrating reed to simple rectification has been mathematically set forth in a book which surveys the field of mechanical and electronic methods.

The commutation is effected at the surfaces of silver-faced contacts. This is practicable because with the inductively

neutralized operation there is not required the usual dissipation at carbon-brush faces of inductively stored coil energy. As confirmed by the literature reporting switching and contacting performances in general, the contact current densities may be made of the order of ten times those practiced with carbon brushes. (Geo. T. Southgate, paper before the *Electrochemical Society* meeting at Cincinnati, Ohio, April 23–25, 1936, abstracted from preprint No. 69-29, pp. 325–331, 3 figs.)

ENGINEERING MATERIALS

Powdered Metals

THE greatest immediate interest from the numerous possible applications of powdered metals is their use as an intermediate product in the manufacture of various special articles. In this connection the author mentions manufacture of comparatively large parts from metallic tungsten. Furthermore, powdered metals, such as copper, are used with the addition of tin to form self-oiling bearings. In this case the pressure used to weld the metal together is not high and the sintering temperature is low, giving a relatively open and porous product with a high capacity for the absorption and retention of oil. (A. B. Everest, paper before the London Branch of the Institute of British Foundrymen, in *Foundry Trade Journal*, vol. 54, no. 1027, Apr. 23, 1936, p. 329)

Fibrous Glass

FIBROUS glass is substantially a new material produced by the Owens-Illinois process by the use of high-pressure steam. The fiber can be controlled as to size from a diameter as little as 0.00015 in. to the coarsest size made, which is 0.0125 in. The fibers can be spun like any textile and have a tensile strength greater than silk, cotton, or rayon. At the present time the chief use of the fibrous glass is as an insulating material for open spaces in house walls and ceilings. In this form it competes with rock wool, which, however, consists of short fibers with high percentage of beads. The fibers are produced from various glasses; for example, those of the same composition as used for bottles.

As the molten glass emerges from the tank, it is subjected to a carefully controlled steam pressure. The fibers are produced through orifices of accurately maintained size and the thickness is controlled by the amount of steam pressure and the viscosity of the glass at the point of drawing.

After forming, the fibers are caught on a continuous conveyor belt and gathered into a continuous mat 30 in. wide by 6 in. deep. This is the fiber used for insulating purposes. The fiber mat is carried to a slicing machine, which cuts it longitudinally and across into sizes appropriate for panel insulation. The panels are stained with streaks of red dye, to permit ready separation when unpacked from the long bags in which it is shipped.

The fibrous glass can also be used for pipe insulation, as a material in air filters, insulation for refrigerators and stoves, etc. It may be of interest to note that the glass fibers are manufactured at a speed of 50 miles per minute. (*Ceramic Industry*, vol. 26, no. 4, April, 1936, pp. 248–250, illustrated)

Hot-Shortness of Aluminum Alloys

HOT cracks are formed in the pasty state of the alloy, when solidification has proceeded not quite to completion. This sort of crack must—as indeed must any other crack—be regarded as a consequence of a load greater than the strength of the material. On that account it is evident that change of strength of the cast alloy and increase of the load during solidification are of great importance in connection with hot-shortness. It is well known that the strength of alloys increases slowly at first, and that a rapid increase of strength occurs only during or after the solidification of the last traces of liquid; this last process takes place in most cases at a constant temperature.

A number of grades of pure aluminum and aluminum alloys were investigated. Most of the castings were produced under conditions similar to those employed in commercial practice. The results are given in a table. A good deal of the work was devoted to the question of how hot-shortness is influenced by structural constituents. This part, however, cannot be suitably abstracted because of lack of space.

An investigation was also undertaken to determine the change in the strength of alloys and the change in the stress arising from checked contraction during solidification. Tensile tests were tried, but showed too much of a spread with the result that bending tests had to be used. The conclusion to which the author comes is that the temperature of the last stage of solidification or the temperature of the incipient melting plays an important part in the phenomenon of hot-shortness.

From results of bending tests carried out with nine alloys, the important conclusion was drawn that knowledge of the strength and of the stress is not always sufficient to estimate the hot-shortness of an alloy. It was also shown that it is possible to derive useful values of the load arising from the thermal contraction with the aid of Hooke's law.

As regards means of avoiding cracks, such factors as mold temperature, weight of mold, cooling factor of the mold, and their influence upon the stress have been examined. (Dr. J. Verö, Dept. of Metallurgy, Royal Hungarian Palatin Joseph University, Sopron, Hungary, abstracted through *The Metal Industry*, vol. 48, nos. 15 and 17, Apr. 10 and 24, 1936, pp. 431–434 and 442, and 491–494, 6 figs.

FOUNDRY

Die Casting of Cast Iron

THIS process was originated by Samuel Price Wetherill and developed under his supervision by the Wetherill Engineering Co., Philadelphia, Pa. It differs considerably from the processes used in die casting nonferrous metals, and one of its features is the use of cast-iron dies with simple liners of cold-rolled steel. It is said that cast-iron die castings have the same chemical analysis as sand castings, but their physical properties are considerably improved. Thus, die castings of 2X foundry iron (ordinary pig iron) have an average tensile strength of 53,000 lb per sq in., which is approximately 20,000 lb more than that of average cast iron.

The article describes in detail the apparatus used and the method of manufacture of the castings.

A pressure of only 20 lb per sq in. is employed to force the metal into the dies. (Chas. O. Herb, *Machinery* (New York), vol. 42, no. 9, May, 1936, pp. 569–574, 5 figs.)

FUELS AND FIRING

Colloidal Fuel

THE problem of the sedimentation of the powdered coal rather than that of the burning of the fuel presents the greatest difficulties in the use of colloidal fuel.

The authors have investigated various factors connected with the stability of coal-oil mixtures and have shown that it is essential for success either to incorporate some chemical in the oil or to treat it in such a way that it tends to set as a jelly when at rest, but behaves

like a liquid when pumped or vigorously agitated.

Several methods of treatment are described in the paper. One is to mix a small quantity of sodium-stearate soap with the oil. A suspension of 40 per cent of pulverized coal, 85 per cent of which was less than $^1/_{400}$ of an inch in diameter, with 60 per cent of Iranian fuel oil in which 0.5 per cent of soap had been dispersed, showed no appreciable separation of the coal after standing at atmospheric temperature for five months. At 100 C, however, the jelly structure gradually disappeared and in 10 hr the coal began to separate. A similar suspension without soap showed signs of settlement after 20 days at atmospheric temperature. In another method described which has been developed at the Fuel Research Station, no deposit of coal after eight or nine months had been found after treatment by blowing air through the heated oil. It is possible, the author states, that by some means involving this principle almost any oil might, although originally unsuitable, be converted into one suitable for forming colloidal fuel. Agitation by air blowing also offers a means of mixing coal with the oil. (Paper by Dr. Manning and R. A. A. Taylor read before Institution of Chemical Engineers, abstracted through *The Steam Engineer*, vol. 5, no. 55, April, 1936, pp. 265–266)

Colloidal Fuel

THE authors, Dr. A. B. Manning and R. A. A. Taylor of the British Fuel Research Board's staff, say that the size of particles of the coal in this fuel ranges from 1 or 2 to 65 microns. The 65-micron size appears to be that generally favored on account of cost of grinding and roughly corresponds to 100 per cent through 100 I.M.M. mesh and 85 per cent through 200 mesh, which is the size now used for pulverized-fuel firing. The authors state that they have no information on the use of colloidal fuel in Diesel engines, but Hamilton Martin stated in the discussion that he had used colloidal fuel successfully in an 80-hp Diesel engine. It was found that the fuel burned more easily than oil or brown-coal dust and that it ignited at some 23 atmospheres pressure as compared with 30 to 45 atmospheres for other Diesel fuels. The authors tell of their observation that in boilers the two constituents burn more or less independently, the oil first and then the coal, so that it is necessary to provide sufficient space for the complete combustion of the slower burning solid particles before the flame impinges on the boiler tubes. The formula has been derived by the authors for calculating the economics of the system showing that the cost of colloidal fuel works out at about 0.99 pence per therm as compared with oil at 1.13 pence.

The authors have followed up the Cunard Steamship Company's work, which showed that some fuel oils, especially those produced by cracking, form stable suspensions of pulverized coal, of the size described as economically producible, without the use of a stabilizer. The properties of oils which are suitable for this purpose have been investigated. With one exception, the origin of which was unknown, all oils found to be suitable were cracked oils. It is found that suitable oils correspond to Iranian oil with sodium stearate addition. They do not appear to possess a clearly defined gel structure, but they "show a type of structure resembling a gel" at low velocity gradients. The viscosity increases as the rate of shear decreases. When any given particle of coal starts to fall through oil it has a very small initial velocity. When many particles are closely packed together, the initial rate of fall is still less: For example, a single particle of coal passing through a 240-mesh B.S. screen will fall through oil at the rate of 0.00167 cm per sec, but with a 40 per cent concentration of coal in the oil, the rate of fall is only 0.00003 cm per sec. At this rate of fall a suitable coal behaves as if it were gelatinous, and the coal is unable to move. When such an oil-coal mixture is stirred—as when it is pumped—it behaves as if the oil were quite fluid and the gel structure had disappeared, but in the course of a few hours the gel structure is re-formed. It was suggested that this loss of "dilute gel structure" upon agitation might prevent the use of oil-coal mixtures at sea where the fluid would rarely be at rest. Apparently the more frequently the oil is agitated, the longer is each succeeding period before the dilute gel structure is re-established. (*Engineering*, vol. 141, no. 3659, Feb. 28, 1936, p. 239)

HEATING

Electric Boilers in Heating Systems

IN this case in the print, pulp, and paper mill at Woodland, Maine, an electric steam boiler is used economically during periods when the river is under control and it is desirable to hold the water in storage. The electric boiler is utilized when the river flow can be controlled to permit the steam plant to shut down week ends.

Before an automatic heating system control was installed it required about 100 tons of coal to maintain steam pressure and supply steam for heating and other purposes over Saturday and Sunday. Now by generating about 200,000 kwhr extra with steam during the week, which can be done with a high-pressure turbine from about 30 tons of coal (4000 Btu per kwhr) the load can be reduced on the hydro plant and the water stored. Then over the week end this water is used in the hydro plant to generate power for the electric boiler when the coal-burning plant is shut down. This operation, combined with automatic heating system control, saves about 100 — 30 = 70 tons of coal each week end when there is not an excess of water.

This is an unusually interesting application of an electric steam boiler to save fuel. It shows that such a boiler may have an important place in power-system operation in low-water periods as well as in high-water seasons. In this particular case the hydro plant has to be operated over the week end to supply the town lighting load and power for other small services. Consequently, it costs practically nothing to produce power for the electric steam generator, other than the cost of coal. Operation of the electric boiler also reduced the amount of labor necessary to keep steam on the plant over the week end. (John P. Topolosky, *Heating and Ventilating*, vol. 33, no. 3, March, 1936, p. 35)

INTERNAL-COMBUSTION ENGINEERING

Armstrong-Sulzer Marine Oil Engine

THE maneuvering gear is extremely simple, only a fuel lever and a starting-air lever, in conjunction with connections to the telegraph, being necessary for the complete control of the engine. The fuel lever is connected with the eccentrics on the fuel-pump regulating valves, and controls the quantity of the fuel, and the timing, to suit the required power. The lever is also interconnected to a servomotor which operates on the fuel-control shaft by means of a high-pressure oil supply.

There are two safety devices in the oil supply to the servomotor. The first of these is the overspeed governor, which is driven by gearing from the crankshaft from the forward end of the engine. If the engine speed exceeds a predetermined figure, the governor shuts off the oil supply to the servomotor, thus cutting off the fuel supply. The second safety device is connected with the engine-room

telegraph and the engine crankshaft. When the telegraph is moved to the "ahead" or "astern" position in reply to an order from the bridge, the oil pressure is opened to the servomotor so that the fuel pumps can be controlled by the hand lever. There is also a trip device which is connected to the same oil control, and driven from the main crankshaft. This device is so arranged that should the engine turn in the opposite direction to that indicated on the telegraph, the fuel is cut off. In addition to the telegraph and fuel and air levers already referred to, the control platform is also provided with a counter and tachometer, together with the usual gages. (*Engineering*, vol. 141, no. 3663, March 27, 1936, pp. 338–339, illustrated)

MACHINE PARTS

Flexible-Shaft Equipment

IMPROVEMENTS in flexible-shaft outfits have embraced all components. Motors are fully equipped with ball bearings and in many cases are enclosed to protect against dust and vapors. They are now designed for operation in a vertical as well as a horizontal position. The entire driving unit swings freely, both horizontally and vertically, adjusting itself instantly to the position in which the handpiece is held, thus causing the least possible bend in the shaft. A great variety of speeds is provided to permit the economical use of a wide range of tools. The cable or core is being made of stronger materials and is more flexible because of the greater uniformity of the wire and other elements entering its construction. Sheaths or casings have been made nonshrinkable, nonstretching, nonleaking, and nonheating.

Maintenance costs of flexible-shaft equipment have been greatly reduced by the development of a special nonraveling cable which permits quick renewal of shafting that has been damaged or is otherwise not operative. When, after long use the flexible cable breaks, it can be replaced in less than 20 min by this new cable carried in stock by the user in the usual mill length of about 25 ft. It may be obtained in the standard music or stainless-steel wire. The latter has the double advantage of lasting longer in service and of being rust free, a feature particularly valuable, as it is not advisable to grease a length of cable kept on hand in customers' stock room. This method of renewing damaged cables requires but little equipment; a vise, a blow torch, and some means of severing the broken cable, such as a cutoff grinding wheel or even a cold chisel and hammer. The repair can be made by any one who has had some experience in soldering. The Kellerflex flexible-shaft equipment includes antifriction bearings of a special type with balls spirally arranged in a bakelite cage, each ball developing its own groove in the race.

The author mentions applications of flexible-shaft machinery; among others, the working of tungsten-carbide dies used for drawing of ferrous and nonferrous shapes. There is a wide variety of attachments for special applications, such as a high-speed device to prevent grinding wheels from wearing down unevenly, as well as burs and rotary files. Of these there are more than 300 different shapes, types, and cuts. Different burs have been developed for different materials.

In this connection it may be pointed out that the Pratt & Whitney Co. has developed a machine for testing and comparing burs of different designs and finishes on materials of different kinds. By means of this research and experimental equipment, the conditions under which burs will function best—what cut and heat-treatment will give the best results on any given material—can be readily determined.

In addition to burs and rotary files, there has been considerable development in polishing and sanding drums applicable to all types of portable tools, including flexible-shaft, and also stationary, equipment. These drums consist of an expanding rubber core mounted on an arbor with two compression washers and nut. An endless abrasive belt or sleeve is mounted on the rubber core, whereupon the core is expanded by tightening the nut. These tools may be used for finishing and polishing steel, brass, bronze, copper, aluminum, and wood, as well as for removing spot-weld marks and solder from sheet-metal work and the like. A prominent present use for them is in the finishing of stainless steel after welding or grinding to bring back the original grain. (H. P. Loewenberg, Keller Division, Pratt & Whitney Co., Hartford, Conn., in *The Iron Age*, vol. 137, no. 15, Apr. 9, 1936, pp. 26–30, illustrated)

POWER-PLANT ENGINEERING

Turbogenerators

IT IS pointed out that the economic crisis put an end to the constantly increasing kilowatt capacity of turbogenerator units. The units built today are nearly always of a capacity below the maximum attainable, which is considered to be, in so far as two-pole machines go, a favorable development because of problems pertaining to mechanical strength of rotors of turbine generators between 50,000 and 100,000 kva, although, as a result of recent considerable development work, satisfactory performance can now, it is said, be guaranteed.

Brown, Boveri & Co. has made some tests on a disk 120 mm long cut from the middle of the cylinder of a single-piece rotor of 860 mm cylinder diameter and 1970 mm cylinder length. While tests in 1923, at the time of the construction of the turbine, showed satisfactory results, a new examination revealed fissures up to 40 mm long in a metal block the outer layer of which was perfectly sound.

Inspection showed that the heat-treatment in itself had not been insufficient but the piece had to be scrapped on account of its many faulty spots. Examination of the whole section by the Brinell hardness method revealed nothing whatever of this fault as the hardness was exceptionally uniform. Analysis made on different radii indicated absence of segregation. A metallurgical examination, however, showed clearly signs of the incomplete transformation of the original structure of the block, these becoming fainter from the inside toward the surface and taking the form of honeycomb-shaped anomalies in peralite, of slag streaks degenerating into fissures, and finally real flaky fissures. Tests were also made to ascertain what stress a rotor would stand up to when it had been proved to be defective but would have been passed as sound according to the testing methods of about 1923.

The interesting conclusion was reached that the local stressings in the rotor after the overspeed test left the piece in a state of internal tension, which manifested itself in compression stressing at the bore of the shaft and tensile stressing in the middle of the radius. It was also discovered that the tension peak at the bore caused very early local expansions. This shows practically that most rotors which are tested at overspeed are characterized, after the test, by an enlarged overstrained bore. This is not necessarily a drawback, because the internal tensions created thereby are opposed to the tensions arising in service and thus reduce the resultant tension peak on the bore. (*The Brown Boveri Review*, vol. 23, no. 1/2, January-February, 1936, pp. 13–16, illustrated)

Producer-Type of Furnace for Steam Raising

THE author starts with a general discussion of gas producers and then proceeds to the consideration of the Lancashire boiler furnace of the producer type, which later, he claims, gives better performance. He mentions the Siemens type of producer in which the grate is inclined and the air passage through the fuel is in a diagonal direction, and finally enumerates the advantages of this type of furnace.

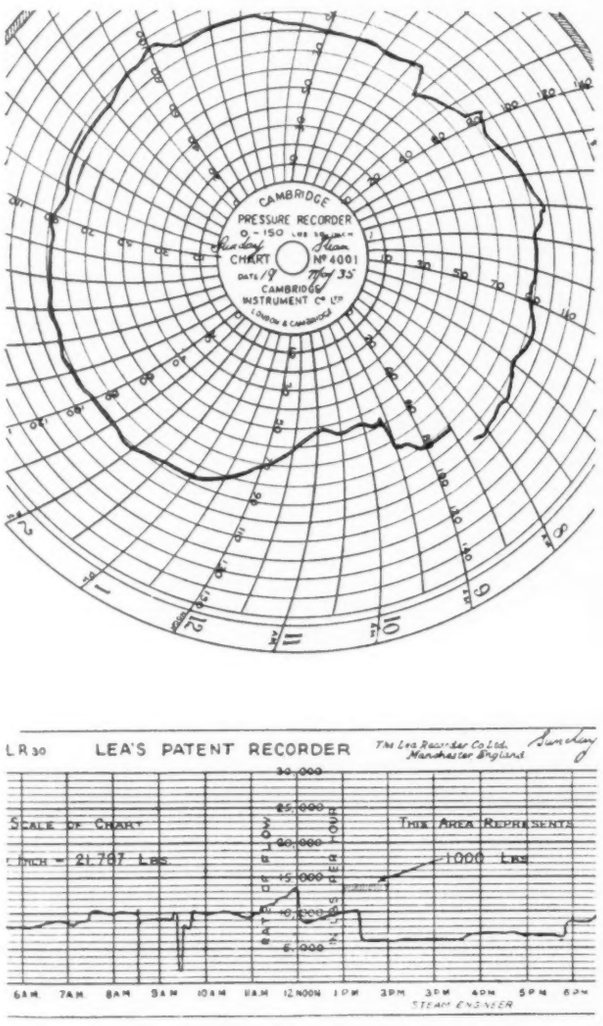


FIG. 2 PRESSURE AND FLOW CHARTS, PRODUCER TYPE OF STEAM GENERATOR

Among these advantages, he says, is the fact that the rate of combustion is independent of the amount of fuel in this producer and determined by the amount of air put through the bed. If, therefore, there be extra steam required, which is apparent from a drop in pressure on the gage, all that is necessary is to open up the air-control valve from the fan. The flame is immediately responsive.

This could hardly be better demonstrated than by the sample charts shown (Fig. 2). These are from an ordinary 30 ft × 8 ft 6 in. Lancashire boiler which would normally be rated for an evaporation of about 8000 lb per hr. It will be seen from the Lea recorder that between the hours of 7 a.m. and 11 a.m. this boiler was evaporating about 9000 lb per hr. At 11 a.m. an extra call for steam came suddenly and the rate of evaporation went up over 13,000 lb per hr and, from the pressure chart, it will be seen that, during this hour, the pressure rose from 50 to 70 lb. This heavy incidental load was met merely by opening up the air valve on the fan.

The outstanding importance of this feature would be evident in any works where there is sudden and erratic steam demand, as, for example, in bleach and dye works, breweries, etc., where it is common practice to have one or more boilers in reserve under banked conditions. In some cases, to meet such emergencies, elaborate and costly steam-storage plants have been put down. With a well-arranged producer-fired boiler installation such elaborations are entirely unnecessary, and a normally rated boiler plant will give, at a few moments' notice, 25 per cent over this rating.

One may conclude with a warning. Literature is issued by certain boiler makers and others in which details of boiler tests are given, these tests generally extending over periods of six or eight hours. One does not dispute the conscientious efforts toward accuracy generally shown by the observers, but it is submitted that these short tests, as guides toward day-to-day performance, are not only useless, but absolutely misleading. Allowance for clinkering and fire cleaning, blowdown, and so on, daily necessities in practical operation, are either omitted or roughly approximated. It is suggested that ordinary firing, conducted with great skill and care, can show decent combustion conditions, and such skill and care are invariably given during these tests. But the following day, ordinary working conditions, fluctuating loads, and so on, are resumed and the thermal efficiency is probably down by 5 to 10 per cent. It is submitted that no boiler test of less than a week's duration is of real practical value. And it is here, where firing skill is of no moment, and when what happens one day is systematically repeated, that the producer firing system really comes into its own. (T. Roland Wollaston, paper read before the Oldham Engineering Society, abstracted through *The Steam Engineer*, vol. 5, no. 56, May, 1936, pp. 322–325, 6 figs.)

RAILROAD ENGINEERING

The Lemaitre Variable Blast Pipe

THE distinctive features of this pipe consist of five convergent nozzles arranged symmetrically around a central nozzle, which is also convergent, but of a larger diameter and at a lower level. Variation of draft is obtained by raising or lowering the "spear" of ovoid form to alter the steam passage in the central nozzle. The subdivision of the steam flow is said to provide a large area of contact between the steam and the flue gases, while the shape and high finish of the nozzle reduces back pressure to a minimum.

This blast pipe was tried on Pacific locomotives of the Northern Railway of France, and it appears, that compared with the Nord blast pipe, the Lemaitre type results in an increase of power which may exceed 200 hp for the same rate of combustion. Alternatively, there is an average saving of fuel amounting to 10 per cent for the same work done. The pipe is also being tested by the Belgian National and the French State Railways.

Owing to the maximum speed limit of 75 mph imposed in France, hard uphill work is frequently called for, and it is under such conditions that a variable blast pipe shows to best advantage, for it enables the driver to modify the force of the blast near the end of the climb and so reduce the rate of steam generation. (*The Railway Gazette*, vol. 64, no. 16, Apr. 17, 1936, p. 738, 2 figs.)

REFRIGERATION

Physics of Extremely Low Temperatures

TEMPERATURES of the order of minus 90 F are already extensively used in the mechanical arts, as for example in the process of shrinking on valve seats in automobile engines. It is apparently merely a matter of development of better processes of generating still lower temperatures before the matter finds application in constructional engineering. The methods of generating these extremely low temperatures are therefore of direct interest to mechanical engineers. According to the author of the present article, the output of the helium-liquefication process as used at the cryogenic laboratories in Leiden and Charlottenburg is only 1/100 of what would have been produced with an ideal isentropic process, which means a process in which the entropy remains constant. The reason for this pitifully low output is that the cooling of the gas is produced not by external work which fundamentally permits a maximum output because of its reversibility, but through inner work.

As has been shown analytically by Meissner the replacement of expansion in the cylinder of an engine or in the turbine by expansion in a throttle valve produces an increase of the amount of air consumption required to create a given output of cold by an amount equal to $-mT_0\int_a^b \frac{vdp}{T}$ where T is the absolute temperature of the system to be cooled, T_0 the temperature of the ambient medium, m the mass of the gas, a initial, and b final pressures. To make the helium that has to be cooled do work in a turbine is impractical because of the dimensions of the turbine necessitated by handling small amounts of helium, even if we forget for the time being the difficulty of operating a turbine at the extremely low temperatures due to the necessity of special heat insulation, the avoidance of frictional heating, possibilities of the failure of lubricants, etc.

It may be remembered that lack of a liquid packing medium made it necessary to give up the idea of using cylinders for the production of external work even in air-liquefaction plants operating at very much higher temperatures than the helium liquefiers. It is because of this that Claude and Heylandt do not liquefy air in a cylinder but employ the latter for cooling only, with the result that they surpass in efficiency by only a very small amount the nonreversible Linde process. The result is that in the present processes air with a boiling point of 80 C is liquefied in the first stage and the boiling liquid used to precool hydrogen (boiling point 20 C) which in turn is used to precool helium (boiling point 4.3 C). All these temperatures are in the absolute scale, centigrade.

Capitza has lately succeeded, however, in eliminating the stage involving hydrogen cooling, which is objectionable because of the danger of explosion. He succeeded by producing an expansion of helium in a peculiar engine. Instead of starting from room temperature, Capitza started from the temperature of air boiling at partial vacuum, this temperature being of the order of 65 C. The helium precooled to 65 C is caused to deliver some external work, which brings down its temperature to 10 C, whereupon it is liquefied by the usual processes of expansion accompanied by internal work.

The success of the Capitza process lies less in the application of new ideas than in the production of a practical machine to do the difficult job assigned to it in this process. In the Capitza machine there is provided a cylinder 31 mm inside diameter in which a piston with a clearance of 0.1 mm and a stroke of 35 to 55 mm runs at a speed of 100 to 120 strokes per minute. The piston effects expansion so fast (0.1 second) that there is only a very small leakage of helium, even though no packing medium is employed. The piston is connected by a tube made of a material of low heat conductivity with another machine working at room temperature. In this second machine water takes up the work delivered by the helium. Notwithstanding the simplicity of the basic idea of this apparatus its construction involved tremendous difficulties.

Apart from the difficulty of finding materials that would satisfy the requirements of proper heat conductivity and strength, it was necessary to find the most desirable dimensions of tubes and valves, to devise a means of guiding the piston so as to avoid side pressures as well as to protect the machine from damage due to congealed particles of air. It is the engineering skill of Capitza rather than his application of physical science that made his little machine work. In the Capitza machine the liquefaction of the helium begins $1^1/_4$ hr after the start and then produces 2 liters of liquid helium per hour with a consumption of only 1.5 liters of nitrogen per liter of helium. Whether this new process with its high thermal and mechanical stresses in the materials used will prove to be as reliable as the older processes remains to be seen. On the other hand, the new process has the great advantage of being free from the danger of explosion in the hydrogen stage.

From this the author proceeds to the description of the magnetocaloric process developed simultaneously by Giaque and McDougall at Berkeley, Calif., and by de Haas and his collaborators in Leiden.

This process will not be described in detail here as information about it is available in the *Physical Review*, vol. 43, 1933, pp. 768 ff; and vol. 44, 1933, pp. 235 ff.

A modification of this process has been worked out by Meissner but he has been unable to find a material to build his valves and elastic cylinders. It is claimed, however, that if a way were found to build his machine, the process would permit reaching temperatures at which dV/dp becomes zero according to the Nerst equation, unless indeed a new point of reversion of dV/dT were found similar to the one at 2.19 C. (E. Justi, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 5, Feb. 1, 1936, pp. 109–116, 13 figs.)

The Frigibloc

THIS type of apparatus has been described before. An interesting development is the Frigibloc with subdivided evaporators so as to obtain two temperature stages. A plant of this description with Frigiblocs for 250,000 kcal per hr at —14 C and 350,000 kcal per hr at 0 C has been ordered recently for a chemical works. The compressor has two suction branches, of which the first is connected to the part of the evaporator for lower temperatures and delivers the refrigerant to the condenser after passing it through six impeller wheels. The second suction branch takes refrigerant from the warmer part of the evaporator, the refrigerant then being passed, together with the vapor from the first circuit, through the last four impellers to the condenser. This two-stage design resulted in a saving of power of about 16 per cent as compared to the refrigeration of the whole in one stage at —14 C. It is pointed out, however, that the two-stage character required a certain alteration in the building and is only suitable when the temperature difference of the stages corresponds to the pressure difference of one impeller, that is to say about 10 C, and when the refrigerating output required at the higher evaporating temperature is sufficiently great and is at least of the

same order as the refrigerating output required at the lower temperature stage. (*The Brown Boveri Review*, vol. 23, nos. 1 and 2, January-February, 1936, pp. 56–57, 3, figs.)

Reversed Refrigeration Plant

THE idea of using a refrigerating system to pump heat from the cold outdoor atmosphere into the warm interior of a building is not new, but is of interest as it permits the use of the same refrigerating system for heating in winter as is used for cooling in summer.

The Virginia Electric & Power Co., Williamsburg, Va., operates, in conjunction with their power plant, an ice-making plant which also heats the building in winter. This arrangement permits the company to make effective use of the condenser-water heat otherwise wasted by an ice plant in the winter. A detail flow diagram for the plant is given in the original article. (*Power Plant Engineering*, vol. 40, no. 4, April, 1936, pp. 235–236, 1 fig.)

SPECIAL MACHINERY

Smith Oil Filter

IN the Smith oil filter the filtering medium consists of specially prepared paper, two circular papers with central holes being separated at the center by two brass washers, one of which has a series of raised pips on one face to space it from the companion washer. The filtering papers are securely fastened together at the periphery and the unit is threaded on to a hollow and perforated stem. A spacing washer is also fitted between each pocket. The filter pack is made up of a number of these units, and the whole sealed into a container carrying the inlet and outlet nozzles.

Dirty oil enters the container and filters through the surface area of the double-faced units; the clean oil passes between the two papers, through the washer spacers to the central stem and back to the sump. (*The Automobile Engineer*, vol. 26, no. 341, January, 1936, pp. 30–32, 11 figs.)

STEAM ENGINEERING

Naval Water-Tube Boilers

THIS is an account of tests and experiments carried out at the British Admiralty Fuel Experimental Station at Haslar on three-drum boilers, with the object of obtaining information regarding the internal working conditions of the boiler, which means the supply of feedwater and its circulation, the changes in the state of the water in circulation, the generation of steam, and its removal from the boiler.

The author begins by showing the typical arrangement of an Admiralty three-drum superheat boiler.

Boilers of this type can be forced to fairly high rates, and the trend of development is toward obtaining the greatest output consistent with efficiency and reliability in order to keep the weight of the boilers and the space occupied to a minimum.

This development results in the boilers becoming reduced in size and weight in proportion to the output obtained, and one important effect of the reduction in size is the reduction in steam reservoir capacity of the boilers.

When the speed of the engines is changed rapidly, this reduction in reservoir capacity makes it necessary to increase or decrease rapidly the output of the boiler to meet the varying requirements for steam.

It is a well-known fact that alteration of the output of a water-tube boiler causes a change in the apparent water level, as indicated by the water gages. When the output is increased the water level rises temporarily in the gage glass and when it is decreased the water level falls temporarily. If changes in output are made rapidly they may, in extreme cases, lead to the passing over of water with the steam, with consequent loss of superheator possibledamage tomachinery or temporary loss of water, resulting in overheating of the boiler tubes.

Investigations have been carried out with an old pattern Yarrow boiler and among other things it has been found that when the output of the boiler was increased the water level in the overall gage fell rapidly below the level indicated in the ordinary water gage. This appears to be due to the fact that when steam is being generated there is in the boiler a mixture of steam bubbles and water in circulation, and as the rate of steam generation is increased the proportion of steam bubbles in the mixture is also increased and causes a reduction of density of the mixture in circulation until at full power its density is approximately two thirds of the density of water at the same temperature. A curve showing the density and different rates of output is part of the original article.

The rapid change in density which will be noted at about one quarter to one half of the full output of the boiler appears to indicate that the rate of steam generation at that output is sufficient to cause a general turbulence in the mixture in the steam drum, with the result that there is a large increase in the amount of steam carried in the water in circulation. Before and after this change has taken place the ratio of density to output appears to vary in a more regular manner. An indicating apparatus for this purpose has been devised.

The effect of changes in density on the circulation in the boiler was next investigated by means of pitot tubes. These investigations indicated that there was, in general, an upward flow in the first four or five rows of tubes from the furnace and a much smaller flow in a downward direction in the remainder of the tubes.

At low outputs there was an upward flow in a larger proportion of the tubes in the tube nests nearer the back wall, i.e., the end of the boiler remote from the oil burners, than in the tube nests nearer the front of the boiler, while at high outputs the conditions tended to level up along the boiler. This appears to be due to the fact that the hot gases pass toward the back of the boiler at low outputs, giving a higher temperature at the back than at the front of the furnace.

Circulation is caused by the difference in density of the mixture in the rows of tubes near the furnace and that in the outer rows as by far the larger proportion of steam is generated in the fire rows. In other words, the head of mixture in the outer rows becomes greater than the head in the fire row.

The generation of steam in the rows of tubes near the furnace produces an increase in volume of the mixture of steam and water as it passes up the tubes, and the velocity of the mixture leaving the tubes will therefore be greater than the velocity when entering the tubes.

The increase in momentum of the mixture as it passes up the tubes is provided by a portion of the head causing circulation. At high outputs it appears that the head required to produce the increase in momentum increases at a greater rate than the head causing circulation with a resulting reduction in the rate of circulation.

This slowing down of the circulation sets a limit to the rate of steam beyond which overheating of the fire rows will occur.

It was found that irregular conditions of boiler feeding affected the indications given by the pitot-tube apparatus, and a sudden change in the feed supply often produced a reduction in the flow in the

fire-row tubes when steaming at high rates. On a number of occasions a reversal of the circulation in a fire-row tube has been experienced, and appeared to be due to a sudden change in the feed supply. It was also found that, with the usual feed arrangements, the results obtained were frequently inconsistent.

It was formerly the practice to introduce the feedwater into the lower water pockets, but this was changed, and the feed led into the steam drums on account of the corrosion which was found to take place in the water pockets and the lower ends of the boiler tubes. The corrosion was caused by the gases which were liberated from the feedwater as it became heated by contact with the boiler water.

With modern closed-feed systems and deaerated feedwater, this corrosion would be less likely to occur.

An examination of the feed-supply arrangements showed that with the internal feed pipe in its usual position, i.e., at approximately the center of the lower part of the steam drum, the relatively cold feed supply was discharged immediately above the fire-row tubes which normally acted as risers, and it appeared that the feedwater tended to flow down the tubes and interfere with the circulation.

For the single internal feed pipe, two pipes were substituted and arranged toward the sides of the lower part of the steam drum to discharge the water outward in order to keep it away from the fire-row tubes.

With the new feed pipes more consistent indications have been obtained with the pitot-tube apparatus.

The change in the position of the feed delivery pipes was found to affect the density of the mixture in the boiler, and comparative trials, show a definite increase in the density due to this change.

The increase in density gives improved conditions for the fire-row tubes, as it produces an increase in the mass flow through those tubes.

These results indicate that the new arrangement of feed pipes should add to the reliability of the boiler by reducing the tendency toward overheating of the fire-row tubes at high powers.

The subject of overheating of fire-row tubes and its prevention is next discussed. (First installment of a serial article presented by Engr.-Capt. S. R. Dight, before the Institution of Naval Architects, Apr. 2, 1936. Abstracted through *The Engineer*, vol. 161, no. 4188, Apr. 27, 1936, pp. 422–424, illustrated)

TESTING AND MEASUREMENTS

Determination of Composition of Dusts

THE size of a particle may be considered as most important when it comes to the determination of properties of dusts. Only dusts which have been produced under closely guarded conditions can have a uniform size of grain, while all the practically important dusts represent a mixture of grains of different sizes. In such a case the question as to size is equivalent to the question as to composition by sizes of the dusts, which means what part grains of different sizes represent in the total mass of the dust.

The determination of the grain composition of dusts is of importance in all processes where the size of the dust particles matters—for example, computation of area of dust particles per unit of weight, as it may affect the course of chemical and physical processes taking place at the surface of dust grains, the estimation of dyes, fillers, binders, etc. On the other hand, as regards the behavior of dust particles in gases and liquids, it is the rate of falling that seems to be most important, in such processes as wind separation, sliming, and sedimentation. This velocity of falling is affected not only by the size of the dust particle, but by its weight per unit of space and by the viscosity and density of the carrying medium, as well as by the accleration due to gravity. Where the velocity of falling of dust particles is of particular importance, it is advisable to consider the composition of the dust not from the point of view of the size of the grain, but from the point of view of its velocity of falling, as this includes at once all the magnitudes which affect it.

The composition according to velocity of falling is of basic importance for the selection and dimensioning of de-dusting machinery. Because of this the characteristic curves for the determination of the composition of dusts in accordance with the size of dust particles and the velocity of flow worked out by the Technical Board for the Study of Dust Engineering connected with the Verein Deutscher Ingenieure is worthy of particular attention. For reasons of convenience and because of the smallness of the units of measurement used in the calculation of the velocity of falling of dust, the "physical" system of measurements has been adopted, facilities having been provided, however, for translating physical units into technical units. The remainder of the article deals with the methods of measurement, which cannot be abstracted here because of lack of space. (Dr. H. W. Gonell, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 21, May 23, 1936, pp. 646–647, 2 figs.)

THERMODYNAMICS

New Auxiliaries for Thermodynamic Calculations

BOIE made calculations of combustion easier by introducing a new coefficient for fuel

$$\rho = (gH + w)/C$$

in addition to the well-known coefficient

$$\sigma = 1 + 3(H - O/8)/C$$

Here H denotes, in parts by weight, the hydrogen, O the oxygen, C the carbon, and w the water content. If the composition of the fuel is unknown, one may employ statistic approximative equations. All the measurements are here made on the basis of the lower heat value H_u. Boie has developed his statistical equations further and shows that with definite groups of fuel, for example practically all solid fuels, a definite average value may be set for the coefficient σ, and the coefficient ρ can in its turn be represented as a function of H_u. These calculations are carried out using the content of carbon dioxide rather than the coefficient of excess of air as a base. From these fundamentals have been developed equations which contain as functions of the lower heat value H_u and content of carbon dioxide, all the magnitudes required for calculations in the field of combustion engineering (amount of air required, amount of flue gases, specific weight, specific heat, heat content, dew point, dissociation). Since there are only two independent variables, it is easy to represent the relations concerned by means of diagrams or tables. Among other diagrams one has been developed for I, H_u, t, of special value for consideration of firing processes.

Goeschel starts also from the observation that the properties of fuels depend on the lower heat value H_u thereof and represents as functions of H_u the content of water vapor and carbon dioxide in the flue gases, as well as their heat content and temperature when combustion takes place without radiation. He shows that for the same temperature of exhaust gases the efficiency of heating surfaces is independent of the degree of air preheating but dependent on the heat content of the fuel.

He treats the transfer of heat separately for the combustion chamber and the contact heating areas. In the combus-

tion chamber the limiting factor of heat radiation is the maximum temperature permissible with a given melting point of the slag. From this can be derived an expression for the load on the combustion chamber which depends on the dimensions of the chamber, the heat value of the fuel, and the excess of air. The heat transmission by radiation increases with air preheating, which raises both the actual temperature difference and the amount of heat that has to be transmitted. The scheme of building a boiler consisting exclusively of a radiating section and an air preheater cannot be put through because the "water value" of the combustion air is materially smaller than that of the flue gases, which means that the air preheater alone is not powerful enough to provide sufficient cooling for the latter. The feedwater heater, therefore, cannot be dispensed with and a reduction of the heating surfaces in the boiler can be obtained only at the cost of the use of large heating surfaces in the air preheater. The author recommends the use of as great velocities of the flow of flue gases as possible, particularly in pressure combustion, but a limit to this velocity is set where solid fuels are used by the errosive action of slag particles. The combination of radiant boilers with air preheaters employing maximum velocities of flow is to be recommended. (Papers by W. Boie and E. Goschel, presented at the meeting of the special board for heat investigation of the Verein deutscher Ingenieure, Oct. 7 and 8, 1935, abstracted through the *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 11, March 14, 1936, p. 308)

New Forms of the Prandtl Equation for Heat Transfer

THE well-known Prandtl equation for heat transfer in the case of a turbulent flow in a pipe can be written as follows:

$$Nu = \frac{\alpha d}{\lambda} = \frac{0.03956\,(Re)^{3/4}\,(Pr)}{1 + A(Re)^{-1/8}\,(Pr - 1)} \quad [1]$$

Here α is the coefficient of heat transfer; d the pipe diameter; λ the coefficient of heat conductivity; and Nu, Pr, and Re, the Nusselt, Prandtl, and Reynolds numbers. To the constant A Prandtl assigned the value of 1.74, but with this value Equation [1] does not agree very well with values determined experimentally. M. ten Bosch has shown that Equation [1] agrees well with values on water obtained by Stender providing $A(Re)^{-1/8} = 0.35$ be assumed. Ten Bosch proposed therefore the following expression for Equation [1]

$$Nu = \frac{0.03956\,(Re)^{3/4}\,(Pr)}{1 + 0.35\,(Pr - 1)} \quad [2]$$

More recently Kraussold, using test data obtained from work with viscous fluids, gave to the Nusselt equation on the following form

$$Nu = 0.024\,(Re)^{0.8}\,(Pr)^{0.37} \quad [3]$$

The present author uses Equation [3] to test Equation [2] in the region of higher Prandtl coefficients. He found that Equation [2] gives considerably smaller α values than Equation [3].

THE KUPRIANOFF EQUATION

Kuprianoff undertook to recalculate the value of A in Equation [1] and found that this magnitude can be expressed

$$A = \text{const}\,(Re)^m/(Pr)^n \quad [4]$$

Equation [1] can be then generally expressed as follows:

$$Nu = \frac{0.03956\,(Re)^{3/4}\,(Pr)}{1 + \text{const}\,(Re)^{m-1/8}\,(Pr)^{-n}\,(Pr - 1)} \quad [5]$$

and if the numerical values obtained by Kuprianoff be inserted therein, the following equation is obtained

$$Nu = \frac{0.03956\,(Re)^{3/4}\,(Pr)}{1 + 0.44\,(Pr)^{-1/8}\,(Pr - 1)} \quad [6]$$

This equation expresses correctly the values of Pr as being equal to from 0.5 to 60, an important range in practical engineering. For the average value of the Prandtl number as obtained from the Stender tests on water (where the Prandtl number varied from $Pr = 3$ and $Pr = 9$), the expression $0.44\,(Pr)^{-1/8}$ gives exactly the value of 0.35 (when Pr is 6.2) as previously determined analytically by ten Bosch.

As regards the starting region where turbulence is formed, one can write for the coefficient of heat transfer $a_L = (L/d)^{-0.054}\,\alpha$, as has been done by Kraussold, which takes into account the relative distance from the beginning of the pipe L/d; the value of α should be inserted from Equation [6].

TEN BOSCH EQUATION

In connection with a previous publication by the present author, ten Bosch pointed out that in accordance with the assumptions made by Prandtl in the derivation of his equation (impulsive transfer of heat in the region of turbulence and conduction of heat through the laminar boundary layer) proper average temperatures must be used in considering both of these processes. The Prandtl equation acquires then the following form

$$Nu = \frac{(\zeta/8)(Re)\,(Pr)}{1 - \varphi\,(Pr_g - 1)} \quad [7]$$

where φ is the ratio of the velocity at the boundary of the laminar layer to the average velocity of the fluid, while the subscript g indicates that the corresponding value belongs to the boundary layer. As regards the Blasius equation for the coefficient of resistance of flow ζ, ten Bosch derives the following equation

$$\zeta = 0.3164\,\xi\,(Re)^{-0.25} \quad [8]$$

and obtains the following value of ξ as a first approximation

$$\xi = 1 - b\,(t_w - t) \quad [9]$$

In this equation the temperature difference $(t_w - t)$ between the wall and the liquid and the factor b showing the heating of the liquid should be positive, and the cooling negative. Tests have shown that $b = \pm 0.001$ for air, and ± 0.007 for water. It is small for oil.

Using as a basis the test data obtained by Nikuradse, ten Bosch obtains the following expression $\varphi = A^1(Re)^{-0.1}$, so that Equation [7] may be written

$$Nu = \frac{0.04\,\xi\,(Re)^{3/4}\,(Pr)}{1 + A^1\,(Re)^{0.15}\,(Pr_g - 1)} \quad [10]$$

For very small temperature differences, $\xi = 1$, $Pr_g = Pr$, and

$$Nu = \frac{0.04\,(Re)^{3/4}\,(Pr)}{1 + A\,(Re)^{0.15}\,(Pr - 1)}$$

With this equation in hand, ten Bosch, using such experimental data as are available, calculated the values of A for air, water, and oil and obtained

$$A = B\,(Pr)^{0.18} \quad [11]$$

Here B is 1.4 when the fluid is being warmed up, and 1.2 when it is being cooled. Ten Bosch also discovered the confirmation of the functional relationship of the factor φ and the Prandtl number. In general the following from Equations [10] and [11] holds good

$$Nu = \frac{0.04\,\xi\,(Re)^{3/4}\,(Pr)}{1 + B\,(Re)^{0.15}\,(Pr)^{-0.18}\,(Pr_g - 1)}$$

By means of this equation all that happens in the turbulent region can, according to Bosch, be expressed, the deviations being less than 5 per cent (J. Kuprianoff, *Zeitschrift für technische Physik*, vol. 16, 1935, no. 13, p. 13 ff and *Zeitschrift des Vereines deutscher Ingenieure*, vol. 80, no. 6, February 8, 1936, pp. 159–160)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

The Noise Problem

To the Editor:

Within the past year or so the interest in noise reduction has been greatly increased. In the preceding few years it appeared that quieting was a refinement that could be retarded for the time, but this period seems to be definitely past.

Perhaps the most striking change in this field is the number of sound meters which have been placed on the market in the last four years. Until a few years ago, one was practically forced to build his own equipment or have one constructed to his order. Stock meters are now available from half a dozen concerns and industry has been buying them in increasing numbers. A few years ago the feeling in industry was quite general that a couple of hundred dollars was sufficient for a noise meter. Now industry is thinking of sound-measuring equipment in terms of thousands of dollars rather than hundreds and this is bound to improve the situation.

Judging from contacts with industrial noise problems for the past decade, I anticipate that many concerns purchasing meters will be greatly disappointed in the results. Sound measurements are an extremely powerful and economical tool, but few practical noise jobs are solved by straightforward readings taken with stock instruments of the type now available. Noise problems seem to contradict all engineering technique so that new backgrounds of fundamentals and experience must be built up. Also many modifications of sound-measuring equipment are needed in practice. Accordingly, in the near future, I suspect we shall frequently encounter statements to the effect, "We went all through this noise-measuring business but it turned out to be no good."

On the other hand, some excellent quieting jobs have been turned out. In the past year a couple of jobs which had not responded to years of work by good engineering methods were satisfactorily solved in a few months application of applied investigation with modern sound-measuring technique. Such achievements are bound to offset the unfavorable experiences. I look forward to an increasing use of sound measurements involving practical noise problems.

Noise Specifications

The question of noise specification is receiving increasingly more attention. The A.I.E.E. held a symposium on noise reduction in January, 1935, and in the discussion at the session, and at the following round table, the subject of noise specifications occupied an important place. The subject was discussed from many angles, including the manufacturers', the users', and the technical viewpoint. At that time, a representative of The Detroit Edison Company stated that they proposed to include noise specifications on all new equipment. A number of attempts have been made to specify noise level for ventilating and air - conditioning equipment. The American Standards Association Technical Committee on Sound Levels and Sound Level Meters has received several requests for data on which to base noise specifications.

The crux of the matter is this: A noise specification is a numerical definition of a human impression of a degree of quietness, and many factors enter into this impression. Thus far, we are not used to expressing our aural impressions in terms of these measurable quantities. While the physical quantities responsible for a given impression can be measured, it often requires considerable work to correlate the physical characteristics of the sound with the psychological impression. Accordingly, a satisfactory noise specification can hardly be manufactured at a desk on the basis of "What constitutes an objectionable level of noise?"

A practical noise specification is based on physical measurements of actual sounds of the type under consideration, together with ratings of these sounds by human observers. In this way the proper physical characteristics can be determined and specified. To date, such information is meager, and hence manufacturers show an understandable reluctance to accept noise specifications.

Until we have built up a background of general experience concerning the reactions of people to sounds of known physical characteristics, it appears that noise specifications are more or less individual problems. I am confident that if measurements can be made on an existing installation, specifications can be written which will insure that another unit in the same installation will give the same results. In many cases the results obtainable under other conditions can be well estimated. As more data become available, more general specifications can be written.

Thus, it appears that we now have the necessary facilities to determine noise specifications for given jobs, and our essential lack is general data which will immediately accrue as the individual jobs are solved.

On page 177 of the January issue of the *Journal* of the Acoustical Society, G. W. C. Kaye states that in England the National Physical Laboratory has undertaken a large program of work on vehicular noise. He states: "As a result, the Committee has submitted proposals to the Minister to forbid the offering for sale or for use on the public highway of motor vehicles which produce noise of loudness exceeding certain prescribed limits." Specific values are mentioned for private cars. Other noise-reduction work is mentioned.

Ernest J. Abbott.[1]

Aluminum Connecting Rods

To the Editor:

The first sentence of Mr. Templin's paper[2] enunciates a condition of locomotive design which has been a periodic worry to locomotive designers who know it to be a fact.

Many locomotives now running on various railroads in this country do not have sufficient available space in the main driving-wheel centers to permit the desired counterbalance, hence the best available compromise had to be accepted,

[1] President, Physicists Research Company, Ann Arbor, Mich.

[2] "Aluminum Connecting Rods," by R. L. Templin, Mechanical Engineering, March, 1936, pp. 169–170.

and, in some cases, this made it imperative to set a speed limit for such locomotives.

The effect of overbalance (usually the amount of counterbalance for reciprocating weights) in a wheel is generally designated "dynamic augment," also "hammer blow," which should be as small as possible.

For locomotives with five or six drivers, coupled, the drivers usually are of small diameter, and the revolving parts hanging from the main pin are so heavy that insufficient space is available for counterbalance of even the revolving weights. For that reason, Mr. Templin's paper is of special interest, as it promises relief and presents test facts carefully determined, which cannot be found in previous publications. Such research work permits perfecting fundamentals of design, such as the American Railway Association "Checking Formulas for Main and Side Rods," adopted in 1914.

The paper presents laboratory and field tests, conducted with great care, on full-size models.

The stress-concentration factors are of extreme interest, since they prove to be in excess of those computed from existing formulas.

In 1930, the Pennsylvania Railroad agreed to make tests of aluminum rods on a 2–10–0 locomotive, class I-1s, which had unavoidably heavy reciprocating weights, resulting in unsatisfactory counterbalance conditions.

Locomotive 4375, selected for the tests, is a limited-cutoff locomotive, having $30^1/_2 \times 32$-in. cylinders, 62-in. drivers, 250 lb boiler pressure, and a rated maximum drawbar pull of 90,024 lb. The total weight in working order is 386,100 lb, of which 352,500 lb is on drivers. The maximum operating speed is 40 mph, and the average operating speed is about 20 mph. For comparison with aluminum rods, a new set of steel rods was prepared. The weights per side are:

	Steel, lb	Aluminum, lb
Main rod	1607	866
Side rod, total	1860	1084
Front	292	181
Front intermediate	838	452
Back intermediate	454	270
Back	276	181

During April and May, 1931, locomotive 4375 was used on the eastern slope of the Alleghenies, between Altoona and Gallitzin, to permit the Aluminum Company of America, in cooperation with the Westinghouse Electric and Manufacturing Company, to take stress measurements on both steel and aluminum rods.

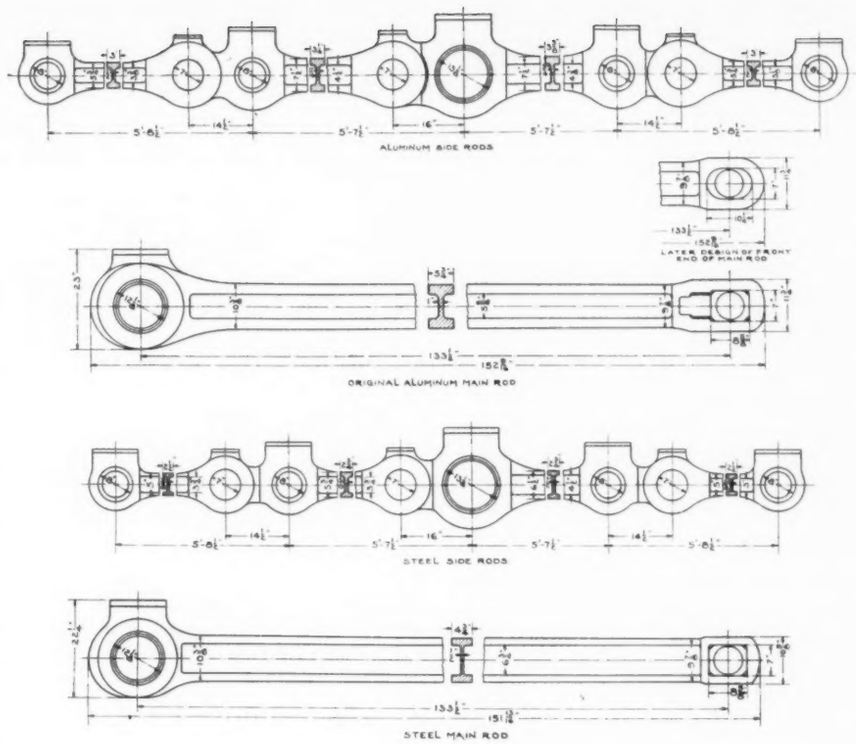


FIG. 1

June 16, 1931, the locomotive, equipped with aluminum rods, was placed in regular service. After making 6065 miles, the right main rod broke through the front eye, on August 11, 1931. At the request of the Aluminum Company, all of the rods were then returned to them for further laboratory tests for fatigue limit.

As a result of these tests, two new main rods with modified front end, shown in diagram Fig. 1, were provided. The side rods had been found satisfactory, and were reapplied.

Locomotive 4375 was again put in service, September 23, 1932. Since that date, these rods have proved entirely satisfactory.

This locomotive, since being equipped with aluminum rods, has been used principally in helper service between Conemaugh and Gallitzin, and, to October 29, 1934, had a total mileage of 63,952 miles.

During that time there were incidents, not related with design or material of the rods, that should be mentioned. Due to its being badly scored by contact with counterbalance rivets and brake shoes or heads, the right back intermediate rod was replaced after 21,077 miles, and the right back section was replaced after 39,793 miles.

Due to derailment, January 7, 1934, the left back section of the side rod was so badly damaged that it had to be replaced, after 45,766 miles.

Because aluminum is a softer material than steel, a larger outside diameter is required for steel bushings to obtain the required tonnage to press them in place; also the knuckle-joint pins become loose sooner and require taking-up.

The dynamic augment per wheel for locomotive 4375, when equipped with steel rods, was $+5.2V^2$, except for main wheels, for which it was $-6.2V^2$; V is speed of locomotive in miles per hour.

With the aluminum rods, it became possible to redistribute the counterbalance weights for reciprocating parts, resulting in a uniform dynamic-augment value per wheel of $+2.6V^2$ for all driving wheels.

A summary of our test to date indicates that, for characteristics of the material used, the proper design for safe aluminum rods, for I-1s locomotive, has been established; that the bearing area of knuckle pins against the aluminum fit is deficient, and should be increased; that a reduction of 40 per cent in weight of rods can be realized, and that this weight reduction permits obtaining desired counterbalance characteristics.

W. F. KIESEL, JR.[3]

[3] Mechanical Engineer, The Pennsylvania Railroad, Altoona, Pa.

M.I.T. Meets Yale in Human-Relations Contest

IN the Stirling Tower at Yale University there took place on Friday, April 17, an event entirely new in the annals of intercollegiate activity: A team from Prof. F. Alexander Magoun's class at the Massachusetts Institute of Technology met a team from Prof. Elliott Dunlap Smith's course in Human Relations in Industry to compete for excellence in the ability to handle a problem in human relations.

The Yale contestants were Hiram S. Cody, Jr., of Winston-Salem, N. C.; Harry E. Sloan, of Hartford, Conn.; and Richard E. Heckman, of New Haven, Conn.; all students in the Sheffield Scientific School. Representing M.I.T. were Brenton W. Lowe, of Fitchburg, Mass., and Claxton Monro, Jr., of Andover, Mass. The judges were Miss Eleanor Little, until recently director for the FERA in Connecticut, Professor Smith, and Professor Magoun.

Each team acted as a composite personnel director for an imaginary company called the "Consolidated Motor Corporation." Two seniors from an outside commercial college—one for each team—were hired to act as applicants and a real attempt on their part to get a job was insured by the payment of a liberal bonus should they succeed in being hired.

The imaginary situation was as follows:

Hiring Situation. The Consolidated Motor Corporation, a combined automobile sales and service organization, has recently opened a Springfield, Mass., agency. The concern is of national scope and while relatively young has a record of sound management, substantial financial backing, profitable and expanding operation. Its employment and personnel policies and practices are well in accord with sound principles. The concern has need of additional personnel both in its offices, sales, and service departments with openings for young men graduating from commercial high school or business college and might possibly be interested in college graduates. The Springfield agency employs 40 people.

Requisitions. The personnel manager has the following requisitions on his desk:

(1) *Stenographer-Bookkeeper.* Young man, graduate of commercial high or business college. To assist in bookkeeping department and take dictation from office manager. May have to substitute occasionally for the general manager's or the service manager's secretaries. For a while a good deal of overtime will have to be put in. Pay about $20.

(2) *Sales Record Clerk, Junior Floor Salesman.* Young man to work on lists of prospects, keep records of salesmen's calls, make appointments for salesmen. Generally assist the sales manager. Will have some chance to try his hand at selling on the floor. Salary $18–$20 to start. Will pay him a commission if he sells any cars.

(3) *Service-Department Clerk.* Young man to work on service-department accounts, records of servicing of customers' accounts. Will have to sell gas and oil and may have to lend a hand at washing cars. If he has some mechanical ability he could make himself useful when there is a rush in the repair department. Will pay him about $15 per week to start.

The teams were required to work out their procedure of interviewing without special coaching from their professors or other faculty members. However, they were free to consult with business men or other people outside the Institute or University and with students who have participated in other class demonstrations of any kind.

In order to make the setting as real as possible the audience sat in a darkened classroom one end of which was furnished like an office and artificially lighted. Each team was allowed 25 minutes to interview its applicant and was required to indicate a definite decision to hire or not to hire at the end of the interview. This did not mean that the applicant must be definitely told that he was or was not hired, but merely that it must be made clear that if a final decision were immediately forced, the answer would be definitely "yes" or "no." An invitation to return for a final interview with hiring dependent upon satisfactory checking of references, or an explanation that the company had no openings, sufficed.

The decision of the judges was based on the following standards:

(*a*) 60 per cent as to which team gave the clearer and more complete picture of the candidate's qualifications, and more clearly produced evidence giving a *sound basis* for the decision which they made.

(*b*) 30 per cent as to which team gave the candidate the best impression of the company (not necessarily pleasantest, but wisest) which he will bear back into the community.

(*c*) 10 per cent as to which team showed the most maturity and finish in their style of handling.

The use of this type of demonstration as a pedagogical device was first conceived by Professor Smith when he was personnel director for The Dennison Manufacturing Co. of Framingham, Mass. So well did it work among the junior executives there that when in 1928 he accepted the Chair of Human Relations in Industry at Yale, Professor Smith introduced the same technique into his classroom with effective results. In 1931 Smith generously taught Magoun his technique; since then the class demonstration has been an important part of the work at M.I.T.

Cornell University and Dartmouth have also followed this lead to some extent. In the courses at Yale or Technology not only is the hiring demonstration a regular part of the curriculum, but selected students attempt the handling of problems in discipline, salesmanship, etc. At a subsequent class, what happened and why it happened is analyzed carefully. Here lies the real value of the demonstration and the art which makes its use by any one except a penetrating expert questionable, if indeed not positively dangerous.

Neither Professor Smith nor Professor Magoun is teaching a "smart" technique by which the college graduate can get his own way, but rather these men are endeavoring to "sensitize the students to the lessons of experience" so that they will become more useful, understanding, and wise members of industry, capable of seeing their problems from all sides.

This first contest was won by M.I.T. Next year the Yale students will travel to Cambridge where the human-relations contest will be held with Technology as host.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of April 24, 1936, and approved by the Council.

CASE NO. 822

(Interpretation of Par. P-301)

Inquiry: May a lever-lifting type of gate valve be used as a blowoff valve under the requirements of Par. P-301?

Reply: It was the intent of the Committee to permit the use of a lever-lifting type gate valve for blowoff purposes where quick-opening type valves are allowable. It is the opinion of the Committee that lever-lifting type gate valves with operating mechanisms which require at least five 360-deg turns of the handwheel to change from full-closed to full-opening and vice versa will meet the intent of a "slow-opening valve" as defined in Par. P-311.

CASE NO. 824

(Special Rule)

Inquiry: May a water-tube boiler, having a total heating surface of not more than 300 sq ft being a unit made up of sections, each section consisting of two seamless steel headers into which the connecting tubes are fusion-welded, be stamped with the Code symbol if the material and welding meet the Code requirements? The boiler is built without longitudinal or circumferential joints in the drum shell or headers.

Reply: It is the opinion of the Committee that for this construction radiographic examination of the welds attaching the tubes to the headers is not required, and the boiler may be stamped as meeting the Code requirements provided that:

(1) the tubes shall not exceed $2^1/_2$-in. outside diameter;

(2) the welding of the tubes to the header complies with the rules for the attachment of nozzles;

(3) the header closures meet the requirements of Par P-198;

(4) each section, consisting of two headers and connecting tubes, be stress relieved and the welds hammer tested; if two or more sections are attached to cross headers by fusion welding, the entire structure shall also be stress relieved as a unit and the joining welds be hammer tested;

(5) the hammer tests of all welds shall be made while under a hydrostatic-test pressure of at least twice the working pressure;

(6) the protective and indicating devices meet the Code requirements.

CASE NO. 825

(Special Rule)

Inquiry: May the front and back sheets of a staybolted box-type header for a water-tube boiler be joined together by fusion welding as indicated in Fig. 32?

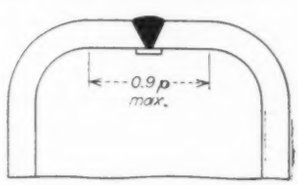


FIG. 32

Reply: It is the opinion of the Committee that the construction covered by the inquiry may be used under the Code rules provided that:

(1) the header is otherwise constructed in accordance with all the other rules of the Code including staybolting;

(2) the staybolt pitch for flat surfaces containing welds does not exceed 90 per cent of that permitted by Par. P-199;

(3) the welded joint is of the double-welded butt type or equivalent;

(4) the welds comply with all the requirements of Pars. P-101 to P-110 and Case No. 751, and the welded structure is stress relieved after the welding is completed, but before the staybolts are inserted.

CASE NO. 826

(Special Rule)

Inquiry: There is no provision in the Unfired Pressure Vessel Code for allowable pressures for steel tubes. What pressures may be used for such tubes in connection with unfired pressure vessels?

Reply: It is the opinion of the Committee that the maximum allowable pressures in Tables P-2 and P-3 of the Code may be increased by 100 lb for use in unfired pressure vessels, and that the same applies to Table P-5 for tubes not to exceed 3 in. diameter.

CASE NO. 827

(Interpretation of Par. P-331)

Inquiry: When a plate is shipped to a fabricator or to a warehouse and is divided into two or more pieces, can such pieces, which carry no plate manufacturer's stamping, be stamped by the fabricator or warehouse?

Reply: It is the opinion of the Committee that an authorized representative of a producer may duplicate the required mill stamping on any material wherever located. Plates at a warehouse not owned and controlled by the mill producing them, or plates in the hands of a fabricator may have additional stamping applied as provided in Par. P-331.

CASE NO. 828

(Special Rule)

Inquiry: Is it permissible under the Unfired Pressure Vessel Code to use nickel-clad material for fusion-welded vessels?

Reply: It is the opinion of the Committee that unfired pressure vessels may be constructed of nickel-clad plates, provided that all Code requirements covering the material of the base plates, welding, and tests for the class of service for which the vessels are intended, are complied with; the allowable pressure for the vessels is computed from the thickness of the base plates without any allowance for the nickel cladding; and that the completed weld or welds have a corrosion-resistant property substantially equal to that of the nickel cladding and such welds are completed before radiographing where this is required.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Industrial Administration

ADMINISTRATIVE PROFICIENCY IN BUSINESS. By Erwin Haskell Schell. McGraw-Hill Book Company, New York, 1936. 292 pp., $2.50.

PSYCHOLOGY OF HUMAN RELATIONS FOR EXECUTIVES. By J. L. Rosenstein. McGraw-Hill Book Company, New York, 1936. 284 pp., $2.50.

PSYCHOLOGY IN BUSINESS AND INDUSTRY. By John G. Jenkins. John Wiley and Sons, Inc., New York, 1935. 388 pp., $2.50.

THE PSYCHOLOGY OF DEALING WITH PEOPLE. By Wendell White. The Macmillan Company, New York, 1936. 256 pp., $2.50.

SOCIAL SECURITY IN THE UNITED STATES. By Paul H. Douglas. Whittlesey House, McGraw-Hill Book Company, New York, 1936. 384 pp., $3.

TOWARD SOCIAL SECURITY. Eveline M. Burns. Whittlesey House, McGraw-Hill Book Company, New York, 1936. 269 pp., $2.

PEOPLE'S WANTS AND HOW TO SATISFY THEM. By Paul T. Cherington. Harper & Bros., New York, 1935. 185 pp., $2.

HOW TO PROTECT BUSINESS IDEAS. By William H. Leahy. Harper & Bros., New York, 1936. 157 pp., $2.50.

REVIEWED BY E. DILLON SMITH[1]

THESE eight books are worthy of special mention among those of the recent flood of books dealing with subjects relating to industrial administration. They are suitable for reference in the undergraduate school and for special study in the graduate school; they present the most recent tendencies in their respective subjects and are extremely timely books. The first six books deal with the psychological and social aspects of industry, the seventh with marketing, and the last with the techniques applicable to the protection of unique features in industry.

Of those works dealing with human-relations problems in industry, it can be safely stated that Professor Schell's (M.I.T.) effort is not only along the same line as his "The Technique of Executive Control," but more advanced and challenging in that it is a simple portrayal of the unique objectives and opportunities which confront the business administrator. This book will be of special interest to the college man who is preparing for future responsibilities of a high order; there is a resonant philosophy upon which to build a career. Dr. Rosenstein (Eli Lilly and Co.) gives an understanding of the "human factor" in industry; from this discussion the student can grasp an understanding of the people whom he will lead and supervise. Professor Jenkins (Cornell) offers "an introduction to psychotechnology" in which he gives those psychological techniques directly useful and applicable to business problems. Here are treated the psychological problems of industrial selection, production, personnel, distribution, and, most important, market research. An appeal to the want for a feeling of personal worth is presented by Professor White (Minnesota). It was in recognition of the need for organized material on "the psychological problem of greatest concern to most people—that of dealing successfully with others—" that this book was written; it is both for individual and for group consideration of problems of personal relationships.

One of the pioneers and chief proponents of social security has been Prof. Paul H. Douglas (University of Chicago). His work discusses the Federal Social Security Act (Public 271, 74 Congress) considering every aspect of it in detail—its origin, chief provisions, and how it will be administrated. The steps by which this act came into being are traced and an outline of some of the problems in the field of social security which lie ahead are given. Dr. Burns (Columbia) has a definite gift for simplifying and clarifying this same act in a different but vigorous and vitalizing exposition. This author believes that the desired result is not achieved in this act; it is merely the first step toward social security. To the industrialist, teacher, student, or economist such comments are most illuminating.

In the new and highly complex field of marketing, Cherington (distribution consultant and sometime professor at Harvard University) points out that the distribution of goods is not through some new "ism," which obscures the real issue, but through a clear view of what people really want. To this end the book is an able discourse.

A simple and compact treatment of the whole story of how to obtain and use to the best advantage trade-marks, patents, copyrights, labels, and kindred properties is treated by Leahy (general counsel of Dennison Manufacturing Co.).

The mark of these books is their freshness; they are worth-while contributions for a more socially minded student who desires increased industrial efficiency.

[1] Member, A.S.M.E. Economics Committee, Economics and Industrial Administration, Pratt Institute, Brooklyn, N. Y.

Books Received in Library

AERODYNAMIC THEORY, a general review of progress under a grant of the Guggenheim Fund for the Promotion of Aeronautics. Vol. 6. Edited by W. F. Durand. J. Springer, Berlin, 1936. Cloth, 6 × 10 in., 286 pp., illus., diagrams, charts, tables, 28 rm. The final volume of this great review of aerodynamic theory contains the following monographs: Airplane as a whole—general review of mutual interactions among constituent systems, by W. F. Durand; aerodynamics of airships, by M. M. Munk; performance of airships, by K. Arnstein and W. Klemperer; hydrodynamics of boats and floats, by E. G. Barrillon; and aerodynamics of cooling, by H. L. Dryden.

AMERICAN YEAR BOOK, a Record of Events and Progress, Year 1935. Edited by A. B. Hart and W. M. Schuyler. American Year Book Corporation, New York, 1936. Cloth, 5 × 8 in., 915 pp., tables, $7.50. This is an annual record of the events, personalities, and tendencies of each successive year in the United States, prepared by a large number of authorities on different subjects. History, governmental activities, business, social matters, pure and applied science, and the humanities are reviewed. A comprehensive index is provided and a wealth of information made quickly available.

ANGLO-RUSSKIY SLOVARI PO SVARKE I REZKE METALLOV. (Glossary of terms relating to welding and cutting of metals.) By W. Shchepkin. Glavnaya Redaktsiya Tekhnicheskikh Zntsiklopediy i Slovarey, Moscow, 1935. Cloth, 4 × 5 in., 164 pp., diagrams. A concise English-Russian dictionary of pocket size.

COMMERCIAL REFRIGERATION. By L. K. Wright. Nickerson & Collins, Chicago, 1936. Cloth, 6 × 9 in., 403 pp., illus., diagrams, charts, maps, tables, $3. This book is intended as a practical guide for designers and builders of small refrigerating plants. The design and equipment of installations using ammonia, methyl chloride, or sulphur dioxide are considered for dairies, bakeries, shops, and factories. Tables, charts, and numerical data are included, largely taken from successful plants.

DYNAMICS OF RIGID BODIES. (Theoretical Mechanics.) By W. D. MacMillan. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 478 pp., diagrams,

charts, tables, $6. This volume concludes the task of writing a series of volumes on various aspects of mechanics which Professor MacMillan undertook about ten years ago, and of which volumes on the statics and dynamics of a particle and the theory of the potential have already appeared. The work provides a thorough course in the theory of the subject, suited to the needs of university students who have a well-advanced training in mathematics.

FORD PRODUCTION METHODS. By H. W. Barclay. Harper & Brothers, New York and London, 1936. Cloth, 9 × 12 in., 219 pp., illus., diagrams, charts, maps, tables, $5. This book describes the equipment and methods of the Ford plant at River Rouge in detail. The work is the result of a comprehensive survey by the author. Numerous charts and a profusion of photographs add to the interest of the book, which will be of value to all those engaged in production methods.

FORTSCHRITTE DES CHEMISCHEN APPARATEWESENS: ELEKTRISCHE ÖFEN. Lieferungen 1, 4, 5, and 6. Edited by A. Bräuer, J. Reitstötter, and H. Alterthum. Leipzig, Akademische Verlagsgesellschaft, 1934–1936. Paper, 8 × 11 in., diagrams; 28 rm. each; 22 rm. each on subscription. This book provides an exhaustive account of the development of the electric furnace, based upon the patents issued by the German government. The text, which is the work of various specialists, describes the outstanding improvements. The second part contains abstracts of all German patents. The third part contains classified number lists of American and British patents. Electrical and structural developments and the uses of electric furnaces in chemistry, metallurgy, and metal working are discussed. The book will be very useful to every student of the electric furnace.

HOW TO BUILD UP FURNACE EFFICIENCY. By J. W. Hays. Dunes Publishing Co., Michigan City, Ind., 1936. Cloth, 5 × 6 in., 559 pp., illus., diagrams, charts, tables, $3 includes set of Ringelmann smoke charts on cardboard. An elementary manual on combustion engineering, intended for the steam engineer and power-plant foreman. Much practical information is given in a chatty, informal way.

HUTCHINSON'S TECHNICAL AND SCIENTIFIC ENCYCLOPAEDIA. Four volumes. Edited by C. F. Tweney and I. P. Shirshov. The Macmillan Co., New York, 1936. Cloth, 7 × 10 in., 2468 pp., illus., diagrams, charts, tables, $25. Over twenty-five years have passed since a cyclopedia of this general nature appeared. During that time new processes, new inventions, and new terms have been introduced in great abundance and the demand for a convenient book of reference has been constant. The present work is an intelligent attempt to meet the need of students and technical workers for quick reference on a great variety of subjects. Terms and processes in pure and applied science, engineering, manufacturing, and the skilled trades are defined and described. Over twenty-five thousand headings are included. Illustrations are numerous and helpful. A working bibliography of three thousand titles is included. The material seems well chosen and the work will be very useful. This reviewer is surprised to find no mention of two common machines, the sewing machine and the typewriter.

INVITATION TO INDUSTRY. By W. A. Rhodes. Christopher Publishing House, Boston, 1935. Cloth, 5 × 8 in., 280 pp., $3. An analysis of possible business expansion based on reducing costs by the transfer of repetitious factory operations to low-wage districts and the grading of goods offered for sale by average district wealth. A theory of utility regulation is also presented, which treats the establishment of rates as a utility function, and the coverage of all profitable customers and competency of operation as the only matters suitable for review by regulatory bodies.

KRAFTFAHRTECHNISCHE FORSCHUNGSARBEITEN, Heft 1. V.D.I. Verlag, Berlin, 1936. Paper, 6 × 12 in., 26 pp., illus., diagrams, charts, tables, 3.50 rm. Increasing motorization of road traffic in Germany has led to the formation of an official board for research in problems connected with that subject. The present pamphlet contains the first publications of the Board. The first paper discusses the relations between the cylinder sizes and numbers of automobile motors and their operating requirements and weights. The second reports an investigation of the stiffness of various body forms. The third reports a study of tar oil as a fuel for high-speed Diesel engines.

LEGAL AND ETHICAL PHASES OF ENGINEERING. By C. F. Harding and D. T. Canfield. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 432 pp., diagrams, tables, $4. The aim of this book is to equip the young engineer with some of the more important legal and ethical principles which must govern his business relations with other engineers and the public. Among the subjects which are discussed are the law of contracts, specifications and estimates, the expert witness, patents, the law of agency and of sales, public relations, and professional ethics.

MACRAE'S BLUE BOOK consolidated with Hendricks' Commercial Register. Forty-third Annual edition, 1935–1936. MacRae's Blue Book Co., Chicago and New York. Cloth, 8 × 11 in., 3380 pp., illus., $15. This well-known guide to buyers has again been revised and brought up to date. It provides an index of manufacturers, indexed under over forty-four thousand headings. Other features are an alphabetical list of manufacturers and wholesalers, a directory of commercial bodies, banks, and other trade facilities in towns of over one thousand inhabitants, and an extensive directory of trade names.

MESSGERÄTE IM INDUSTRIEBETRIEB. By G. Wünsch and H. Rühle. Julius Springer, Berlin, 1936. Cloth, 6 × 10 in., 315 pp., illus., diagrams, charts, tables, 26.70 rm. This is a comprehensive review of industrial measuring instruments, intended for use as a textbook and a guide for the commercial user. The general principles of measuring and recording apparatus are first discussed in detail, after which the special processes and instruments used for measuring pressures, temperatures, the flow of fluids, the contents of containers, and the composition of gases are described.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, bd. 4, heft 4, February, 1936. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., illus., diagrams, charts, tables, 2.90 rm. This number contains the conclusion of the paper on modern steam-hoisting engines; a description of the three twin-screw motorships built for the Argentine government in 1934; a description of the M.A.N. Diesel engine which won first prize in the Russian Diesel truck trials in 1934; and a discussion of analytical methods for controlling the composition of cement.

MITTEILUNGEN DER MATERIALPRÜFUNGSANSTALT AN DER TECHNISCHEN HOCHSCHULE DARMSTADT, Heft 6. GUMMIFEDERUNGEN FÜR ORTFESTE MASCHINEN. By A. Thum and K. Oeser. V.D.I. Verlag, Berlin, 1935. Paper, 6 × 9 in., 72 pp., illus., diagrams, charts, tables, 6.50 rm. The use of rubber to dampen the vibrations of machinery is discussed both theoretically and practically in this book, the first on this specific subject. The elastic properties of rubber are described, formulas for designing rubber dampers are developed, and examples are given of their use in the foundations of engines, etc.

MITTEILUNGEN DER MATERIALPRÜFUNGSANSTALT AN DER TECHNISCHEN HOCHSCHULE DARMSTADT, Heft 7. VORSPANNUNG UND DAUERHALTBARKEIT VON SCHRAUBENVERBINDUNGEN. By A. Thum and F. Debus. V.D.I. Verlag, Berlin, 1936. Paper, 6 × 9 in., 72 pp., illus., diagrams, charts, tables, 6.50 rm. This report, based upon extensive research work, is intended to provide a basis for the design of durable bolted connections. The behavior of bolts under the initial tension is discussed, methods for measuring initial tension and working stresses are described, and the results of measurements are given. The practical use of these data is also finally described.

ÖSTERREICHISCHES PETROLEUMINSTITUT (ÖPI-Veröffentlichung Nr. 2). Zur Frage der Veränderung von Schmierölen im Gebrauch und ihrer Regenerierung. Edited by H. Kamptner. Verlag für Fachliteratur, Vienna, 1935. Paper, 6 × 8 in., 23 pp., tables. This pamphlet, prepared by the Austrian Petroleum Institute, provides a critical review of the literature upon the reclaiming of crankcase oil. The results of practical experiments are given, with conclusions.

QUANTUM THEORY OF RADIATION. By W. Heitler. Clarendon Press, Oxford, England; Oxford University Press, New York, 1936. Cloth, 6 × 10 in., 252 pp., diagrams, charts, tables, $6. This book is said to be the first to present a systematized account of the theory from a uniform point of view. After an introductory chapter on the classical theory, the quantum theory of radiation is developed in the simplest form of general validity. The fundamental applications to atomic physics are then discussed.

REPORTS ON PROGRESS IN PHYSICS, vol. 2. Edited by A. Ferguson, published by Physical Society, London; printed at University Press, Cambridge, 1936. Cloth, 7 × 10 in., 371 pp., diagrams, charts, tables, 21s, $5.25. This is the second annual volume of a series which is intended to supply the physicist with reviews of recent developments in this field, prepared by competent specialists. This volume contains reviews on general physics; the quantum theory; atomic physics; geophysical prospecting; radio exploration of upper-atmosphere ionization; sound, heat; electrical and magnetic measurements; the charge of the electron; electron tubes; X-rays; spectroscopy; and optics. Each article is accompanied by a bibliography.

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

HILDING TÖRNEBOHM, Calvin W. Rice Lecturer at Dallas, Texas, June 17, 1936, was graduated from the Royal Technical University, Stockholm. For a year he was instructor at the university in theoretical mechanics, following which he became chief engineer of the Swedish Machine Works, Ltd., a position which he held until 1917. For two years thereafter he was assistant professor in the design of machine tools at the Royal Technical University. He left the University to become chief engineer of the Swedish Gear Manufacturing Company, which was later absorbed by SKF, where Mr. Törnebohm was first, chief designing engineer, subsequently, chief engineer, and today, chief engineer and manager of the technical bureau.

Mr. Törnebohm's outside technical appointments have been numerous. Since 1918 he has been a member of the Swedish Committee for the Standardization of the Mechanical Industry, and has been president of the committee. He has represented Sweden at all of the International Standardization Conferences and has on occasions been chairman. He is today president of the Swedish Tolerance Committee; president of the Swedish Committee for the Standardization of Ball and Roller Bearings; member of the Standardization Committee of the Swedish Mechanical Industry; member of the Committee of the Iron and Steel Institute for the standardization of tolerances and dimensions of commercial iron; member of the International Subcommittee for I.S.A.-3 Tolerances; member of the Board of Directors of the Volvo Automobile Company; and president of the Board of Directors of the Lidköping Engineering Works.

In 1928 he was awarded the gold medal of the Royal Engineering Academy for his work in connection with the establishment of a Swedish tolerance system.

On June 13, Stevens Institute of Technology conferred an honorary degree on Hilding Törnebohm, "an engineer both scholarly and dynamic, influential at home and abroad, particularly in those conferences of engineers where are determined the standards of the mechanical industries of the world."

HOWARD I. SMITH, co-author with RICHARD V. AGETON of paper in this issue on "Mechanization of the Potash Mines in New Mexico," has been chief mining supervisor since 1921 of the U. S. Bureau of Mines and the U. S. Geological Survey, Washington, D. C. He was graduated from Pennsylvania State College in 1907 and served there for a year as an instructor, following which he became associated with the Corona Copper Company in Arizona. In 1910 Mr. Smith joined the engineering construction corps of the Atchison, Topeka, & Santa Fe Railway, and the following year entered the employ of the U. S. Bureau of Mines. From 1917 to 1919 he served as assistant general superintendent of the Vandalia Coal Co., in Sullivan, Ind., and was then for a year a member of the American Technical Mission in Yugoslavia. He is the author of a number of publications on coal analysis, mine ventilation, mine timbering, mine accidents, and the development of the New Mexico potash deposits.

Mr. Ageton, co-author with Mr. Smith, is deputy mining supervisor in the mineral-leasing division of the U. S. Geological Survey at Carlsbad, New Mexico. He attended the Montana Agricultural College, Montana Wesleyan University, and Washington State College, and received the degree of B.S. in mining engineering from Washington State College in 1911. After a varied mining experience in the western states Mr. Ageton entered the employ of the government in 1917 and has since been associated with the Bureau of Mines and later with the Geological Survey.

W. E. SYKES, who writes on "Gear Noise—Causes and Corrections," invented and developed the Sykes gear-generating machines and other gear-manufacturing equipment and testing instruments. He was born in England. After a course at the Huddersfield Technical College of Leeds University, he joined the firm of David Brown & Sons in 1902, gaining a wide experience in the various departments of that concern. In 1908 Mr. Sykes became works manager of the Power Plant Company, Ltd., England. In 1922 he sold his United States patents to the Farrel-Birmingham Company, Buffalo, N. Y., and since then has continued development of his various inventions. In 1927 he established his own factory in England and has been dividing his time between the two countries. In 1934 Mr. Sykes was awarded the Edward Longstreth Medal by the Franklin Institute.

W. R. WOOLRICH, member A.S.M.E. and director of the Agricultural Division of the TVA, writes on "Process Industries and Rural Stability." Professor Woolrich is a graduate of the University of Wisconsin where he received the degree of B.S. in electrical engineering in 1911 and the degree of M.E. in 1922. He served as an instructor for a year in DePaul University and then became assistant methods engineer with the Western Electric Co. From 1913 to 1916 he was connected with the International Harvester Co., Chicago, as supervisor of apprentices and then as methods engineer. He resigned to become a member of the faculty of the University of Tennessee as professor of mechanical engineering. Professor Woolrich is the author of numerous technical papers, the "Handbook of Refrigerating Engineering," and joint author with W. E. Biggs of the "Handbook of Steam Engineering." He is a member of Phi Beta Kappa, Tau Beta Pi, the American Society of Refrigerating Engineers, the National Association of Power Engineers, the National Association of Practical Refrigerating Engineers, as well as of many clubs. He has served the A.S.M.E. on its Nominating Committee and the Committee on Local sections, and is at present a member of the executive committee of the Process Industries Division.

HERBERT R. ISENBURGER, president of the St. John X-Ray Service, Inc., is the author of the paper on "Radiographic Inspection of Welded Refinery Equipment." Mr. Isenburger was born and educated in Germany. He has been associated with Dr. Ancel St. John since 1927, specializing in radiographic inspection work as well as in the design and installation of such equipment; the training of operators; and X-ray diffraction analyses. He is the author of many technical articles in this field as well as co-author of the book "Industrial Radiography." He is a member of the Association of Consulting Chemists and Chemical Engineers.

Another in the series of reviews of current economic topics of interest to mechanical engineers is "The Federal Social-Security Plan," contributed by JOHN SHUTE, a member of the Department of Economics, Massachusetts Institute of Technology.

Publication Procedure for A.S.M.E. Papers

THE following statement to sponsors of meetings of The American Society of Mechanical Engineers was approved by the Executive Committee of the Council at its meeting of May 21, 1936. The statement is intended to clarify policies and procedure with respect to publication of papers delivered before meetings sponsored by A.S.M.E. groups.

TO SPONSORS OF A.S.M.E. MEETINGS:

At its meeting of April 10 the Advisory Board on Technology voted to request all agencies of the Society engaged in conducting technical meetings to send to headquarters all manuscripts of papers to be presented so that the Committee on Publications might have an opportunity to publish them in Transactions of MECHANICAL ENGINEERING.

Papers should not be released to the trade press for printing before the meeting without consultation with the Committee on Publications.

Sponsors of the meetings are requested not to enter into arrangements with local printers for printing papers for sale and distribution at the meeting without the advice and consent of headquarters and the appropriate committees.

It is the hope and intention to have as many papers as possible published through regular A.S.M.E. channels and the foregoing suggestions are in the nature of providing the machinery for cooperation between the Publications Committee and the various agencies of the Society who are arranging for papers and programs. This does not mean that in the future it may not be desirable at times to provide for publication other than through the Society. It is, however, desired that the Society shall have first call upon all such papers.

ADVISORY BOARD ON TECHNOLOGY

Actions of A.S.M.E. Executive Committee

AT A meeting of the Executive Committee of the Council of The American Society of Mechanical Engineers, May 21, 1936, the following actions of general interest were taken:

JOINT DINNER, ENGINEERING SOCIETY BOARDS

It was announced that a joint dinner of the boards of the Founder Societies had been proposed by the United Engineering Trustees to be held on October 21, 1936.

MEMBERSHIP STATUS

On recommendation of the Board of Review it was voted to extend to December, 1936, the present policy of canceling dues and placing members in inactive status, pending a complete report by the Board of Review.

BUDGET REVISIONS

An upward revision of estimated income from publication sales resulted, on recommendations of the Finance Committee, in authorization of increases in expense for the following: Publication sales, office expense for publication sales, student branch operation, office expense for student branch operation, addition to surplus, and Transactions.

BANK DEBT PAID OFF

The Finance Committee reported that the Society's bank debt had been completely discharged.

TRUST FUNDS

Upon recommendation of the Finance Committee authorization was voted to carry out plans for putting such funds on an improved basis.

TERM "ENTHALPY" ADOPTED

Upon recommendation of the Committee on Research it was voted to adopt the report of the Special Research Committee appointed to select an appropriate name for the thermodynamic function commonly called "total heat" or "heat content," which recommends the use of "enthalpy" in future publications of the Society whenever feasible, the publication of this report in MECHANICAL ENGINEERING, and sending copies of this report to other engineering and scientific societies.

ADVISORY BOARD ON TECHNOLOGY

A proposed communication to sponsors of A.S.M.E. meetings relating to publication of papers (see pp. 464–465 of this issue)was approved on recommendation of the Advisory Board on Technology.

APPOINTMENTS

Appointments to standing and special committees and of Society representatives were reported, as follows:

Graphic Arts Division Executive Committee—A. E. Giegengack (unexpired term of E. P. Hulse, expiring 1940)

National Research Council, Division of Engineering and Industrial Research—R. C. H. Heck (1937), W. Trinks (1939)

U.E.T. Fund Raising Committee—E. J. Billings, R. Kutzleb, C. E. Brune

A.A.A.S., Section M, Atlantic City Meeting, December 28, 1936, to January 2, 1937—Geo. F. Bateman, Crosby Field.

Eleventh Annual Aircraft Engineering Research Conference, Langley Field, Hampton, Va., May 22, 1936—Alexander Klemin

MEETING OF JUNE 3

A meeting of the Executive Committee of the Council of The American Society of Mechanical Engineers was held on Wednesday, June 3. Actions of the Committee of general interest follow:

MEMBERS' VIEWS

In discussing the function of the Local Sections Delegates Conference as an agency for bringing out points of view of members on questions of Society policy, Walter Rautenstrauch pointed out that substantial progress had been made in scientific methods of determining cross sections of public opinion. He was therefore requested to develop and present a practicable scheme that the Society might put into effect.

EMPLOYMENT

As an aid to the National Employment Committee in setting up a program, the Committee voted to express its realization of the need for an effective employment service for engineers operated jointly by the engineering societies, to pledge continued financial support to such a service, and to state its conviction that such a service can be placed on a self-supporting basis.

BUDGET POLICIES

The Committee discussed and recommended to the Council for adoption a statement of policies to guide the setting up of a Society budget for 1936–1937, and a schedule of income and expense for consideration at the Dallas meeting of the Council.

CONSTITUTIONAL AMENDMENTS

Proposed changes in the Constitution and By-Laws of the Society were considered and the Committee on Constitution and By-Laws was requested to withhold the changes from formal action until the Annual Meeting in December. The Council will discuss the proposals informally at Dallas.

B. OF M. RESEARCH AGREEMENT

It was voted to renew for the fiscal year beginning July 1, 1936, a cooperative agreement between the Society and the United States Bureau of Mines relating to research on removal of ash as molten slag from powdered-coal furnaces. The agreement relates to experimental work being done at the Pittsburgh Experiment Station of the Bureau.

TRANSFER FROM STUDENT TO JUNIOR-MEMBER GRADE

It was voted to send a letter to the students graduated in June 1935, who have not yet become junior members, informing them that they are eligible to junior membership by the payment of $2.50 before July 6, 1936.

It was further voted to record the Committee as favorably inclined to the following regular procedure for the transfer of student-members to junior membership: Graduates at the end of the first term each year will be billed for $5 for dues from April 1 to the end of the fiscal year; graduates in June will be billed for $2.50 for dues from July 1 to the end of the fiscal year; to record the Committee as favoring a scheme whereby the student may pay the foregoing amounts before graduation and be given an opportunity to purchase a membership certificate and a pin; and to encourage arrangements with the various institutions whereby the membership certificate and the pin would be presented to the student with his graduation diploma on commencement day.

MEMBERSHIP GRADES

Discussion of policies in connection with administration of the new membership grade of fellow was participated in by members of the Committee on Admission, and that committee was requested to present a comprehensive plan for further discussion by the Council at Dallas.

APPOINTMENTS

The following appointments to special committees were reported, as follows:

Special Research Committee on Lubrication (reorganized): O. C. Bridgeman, W. E. Campbell, Hans Dahlstrand, H. A. Everett, A. E. Flowers, R. D. Geniesse, Raymond Haskell, M. D. Hersey, G. B. Karelitz, L. P. Michael, S. J. Needs, G. L. Neely, B. L. Newkirk, A. E. Norton, J. F. Pelley, and E. Wooler. Power Test Codes Committee No. 19 on Instruments and Apparatus: J. W. Johnson.

A.S.M.E. Annual Meeting, Nov. 30–Dec. 4, 1936

THE Fifty-Seventh Annual Meeting of The American Society of Mechanical Engineers is to be held in New York, November 30 to December 4, 1936.

Plans for the technical program are under way and will include some new features. Of special interest will be a two-session symposium on corrosion-resisting metals, scheduled for Thursday afternoon and evening, Dec. 4.

An innovation this year will be technical sessions on Monday and Thursday evenings, to avoid crowding the program and conflict with other daytime sessions. The subjects will be of general interest.

Two panel discussions are being planned, one to be held on Tuesday afternoon, sponsored by the Fuels Division.

Sessions already scheduled include one on

aeronautics, two on fuels, one on boiler feedwater, one on heat transfer, one on railroad engineering, one on fluid meters, three on power, two on machine-shop practice, one jointly by the Process Industries and Textile Divisions, one on oil and gas power, three on management, one on mechanical springs, one on hydraulics, one on materials handling, one on metals at high temperature, one on safety, and one on the history of the steam turbine.

Members desiring to submit papers for presentation at the Annual Meeting must notify the Committee on Professional Divisions before August 1, and must send to the committee a three-hundred word abstract of the proposed paper. In order to facilitate preprinting of papers, manuscripts must be sent to headquarters before September 1.

A.S.M.E. Niagara Falls Meeting, Sept. 16–19

THE Niagara Falls Meeting of The American Society of Mechanical Engineers will be held September 16 to 19. Technical sessions dealing with power have been especially arranged to coordinate with the study tours of the World Power Conference announced elsewhere in this issue.

The present plan for the power and fuels sessions is to present three papers on Thursday morning, September 17, covering a review of practice in superposition and power-station design in the United States. The afternoon session will provide papers on German and British boiler and turbine practice. On Friday morning, September 18, there will be a session on fuel problems with papers from Germany, Great Britain, and the United States.

The hydraulic program will consist of a session on hydraulic research in the United States, scheduled for Friday morning, and a session in the afternoon reviewing turbine practice in the United States and Canada with discussion by visitors from abroad.

The A.S.M.E. Railroad Division is sponsoring a session on Thursday morning to discuss Diesel locomotives and freight-yard classification equipment.

Four other Divisions will hold sessions at the Niagara Falls Meeting. Two papers will discuss handling in processing industries. The Process Industries Division will sponsor two sessions on drying and process-industries developments. The Aeronautic Division will provide one session, and the Wood Industries will have either one or two sessions with special arrangements for a plant-inspection trip.

Other interesting features that are being planned for the meeting will be announced in a later issue. These will include stop-over excursion trips before and after the Niagara Falls Meeting.

A.S.M.E. Policy on Expositions

IN RESPONSE to a request received from Fred H. Dorner, member, A.S.M.E., of Milwaukee, the Executive Committee of the Council of The American Society of Mechanical Engineers has authorized a statement with respect to the relationship between the Society and expositions, such as the Power Show frequently held in New York at the time of the Annual Meeting of the Society. The statement follows:

The American Society of Mechanical Engineers has no financial or administrative connection with any exhibition or exposition dealing with power or mechanical engineering. Although the Society has for many years encouraged expositions of mechanical equipment held simultaneously with meetings of the Society, it has derived no income from any of the agencies operating these expositions nor has it contributed anything toward defraying the expense of carrying on these expositions.

Gantt Medal Awarded to Morris E. Leeds

FOR distinguished achievement in industrial management as a service to the community, Morris E. Leeds, president, Leeds & Northrup Company, Philadelphia, Pa., has been awarded the Henry Laurence Gantt Gold Medal.

This medal has been awarded annually since 1929 by the Institute of Management, Research Group of the American Management Association, to individuals selected by a committee of award, half of whom are appointed by the Institute and half by The American Society of Mechanical Engineers.

The award memorializes the distinguished achievements and great service to the community rendered by Henry Laurence Gantt, member, A.S.M.E., management engineer, industrial leader, and humanitarian. The first gold medal struck was bestowed posthumously upon Mr. Gantt in accordance with the wishes of the donors of the award.

World Power Conference, Washington, D. C., Sept. 7–12

THE Third World Power Conference, and the Second Congress on Large Dams, will be held concurrently in Washington, Sept. 7–12, 1936.

The program of the Third World Power Conference has two distinct parts—the general program of the Washington discussions and the technical program of the study tours. The theme of the former is "The National Power Economy" considered in its broadest sense of energy sources, development, and utilization. There will be discussion of its physical and statistical basis and of technical, economic, and social trends, of the organization of the fuel industries and of gas and electric utilities, of conservation of natural resources, of national and regional planning, of rationalization of energy distribution, and of national policies with respect to power and power resources.

It is the plan to have every participating country submit a national paper on each of the program topics which has any significant bearing on its power problems. The general program was announced in the May issue of MECHANICAL ENGINEERING, pages 337–338.

The papers will be condensed into "general reports" prepared by official reporters and printed in the four languages of the conference. Both papers and reports will be printed and in the hands of delegates and members well in advance of the meeting, but may not be released for publication prior to their discussion in the meeting. Neither papers nor reports will be read, but the sessions of the conference and of the congress will be devoted exclusively to oral discussion.

CONGRESS ON LARGE DAMS

The program of the Second Congress on Large Dams is strictly technical. Formal papers will be presented on a limited number of technical questions selected by the central office of the International Commission on Large Dams, and these will be discussed at the congress. In addition, brief reports known as "communications," on certain other selected subjects, will be published in the transactions of the congress, but are not intended for discussion at the sessions.

STUDY TOURS

In addition to the formal program of the sessions in Washington, the American National Committee is organizing another program to deal exclusively with technical subjects and to be conducted in the course of study tours, so arranged as to permit the detailed examination of the most modern plants, processes, and practices in the United States. At least one day on each of these study tours will be devoted to round-table discussions carefully planned in advance and led by experts intimately acquainted with and able to interpret what has been seen. Each of these study tours, lasting from six to ten days, will be offered before and after the conference.

The tours are being planned as all-expense trips, and it is planned to hold expenses to a maximum of $10 a day. Competent tour managers will accompany each party, attending to details of travel.

Plans are being completed to give the following tours, starting on the dates indicated:

Tour No. 1, on sources of power, will leave New York on the evening of August 31, visiting Detroit, Cleveland, and Pittsburgh, and arriving in Washington on September 6.

Tour No. 2, embracing dams, hydroelectric stations, hydraulic research, and the Tennessee Valley Development, will leave New York on the afternoon of August 27, visiting Boston, Pittsburgh, Zanesville, Knoxville, and the Tennessee Valley Development, reaching Washington on September 6.

Tour No. 3, embracing steam-power developments, electrical equipment, transmission and distribution, and industrial research, will leave New York on the evening of August 27, visiting Albany, Schenectady, Niagara Falls, Buffalo, Detroit, Cleveland, and Pittsburgh, reaching Washington on September 6.

Tour No. 4, a railway tour, which will cover railway transportation, railway electrification, and terminal operations will leave New York on the morning of August 28, visiting Schenectady, Chicago, and Pittsburgh, reaching Washington on the morning of September 5.

The post-conference tours will be essentially duplications of the pre-conference tours, except that all will start either on the evening of September 14 or the morning of September 15 from New York and will finish in New York.

An extensive transcontinental tour has been scheduled after the Conference. This trip, approximately three weeks in duration, will take visitors into Canada and all the way across the United States, taking in the great western power developments, including Boulder Dam. This tour will be arranged at low cost and will afford an opportunity of seeing the whole of the vast United States in a style and price probably never before equaled.

CANADIAN AND NIAGARA FALLS MEETINGS

The Canadian National Committee of the World Power Conference has invited participants in the transcontinental tour, and all other delegates and members of the conference and the Congress who may be able to do so, to visit Canada immediately after the conference. Visitors will be entertained by the Canadian Government at Ottawa and by the Provincial Governments of Quebec and Ontario at Montreal and at Niagara Falls.

As announced in the June issue of MECHANICAL ENGINEERING, page 403, a meeting of The American Society of Mechanical Engineers will be held at Niagara Falls, Sept. 16–19, to synchronize with this visit to Canada. Further news of this meeting appears on page 466 of this section.

MEMBERSHIP TERMS

Any person upon the payment of the $10 registration fee may become a member both of the Conference and the Congress. Applications for membership should be made through the National Committees, through the International Commission on Large Dams, or directly to the Third World Power Conference, Interior Building, Washington, D. C. No registration fee is required of official delegates.

Registrants will be entitled to receive a badge, to be admitted to all sessions of the conference and congress, to participate in all tours at their own expense in so far as accommodations are available, to participate in such entertainment as may be provided either with or without additional cost as the case may be, and to have the benefit of any discounts or special rates in general transportation or hotel accommodations as may be secured by the American National Committee.

The women accompanying delegates or members will have the same status and privileges as the delegates or members without payment of any registration fee.

Engineering Foundation's Platform

A NEW "platform" of The Engineering Foundation, to supersede that of 1925, was adopted in 1935 and approved by the Board of Trustees and by the Founder Societies, the A.S.C.E., A.I.M.E., A.S.M.E. and A.I.E.E.

Guided by experience in twenty years characterized by profound changes in science, engineering, economics, industry and political organization; assisted by many expressed opinions of members of its Founder Societies and friends; and encouraged by commendations and additional gifts from its founder, Ambrose Swasey, and other persons, The Engineering Foundation Board, without limiting the discretionary power bestowed by the Founder and the Founder Societies through its broad charter, expressed its general plan and policy for the near future in the following platform:

GENERAL PLAN AND POLICY

1 The Engineering Foundation recognizes the responsibility of leadership placed upon it for attaining the objectives set forth in the deed of gift.

2 The Foundation will concern itself with human as well as technical aspects of engineering problems of wide interest. Activities which will have as their main objectives "the advancement of the profession of engineering," whether by research or other means, will be given preference.

3 The Foundation will initiate new projects or will select from time to time projects presented to it which are deemed most likely to attain its objectives.

4 In examination of proposals and in development of those selected the Foundation will seek the collaboration of members or committees of its Founder Societies especially conversant with the subject under consideration. It will also seek other counsel as needs arise.

5 It will assist in developing selected proposals into organized projects, and will choose a competent agency for the conduct of each project, when in approved form.

6 It will assist approved projects, according to the needs of each, by grants of money, by solicitation of contributions of money, services and materials, and in other ways.

7 Responsibility for development and prosecution of each project shall rest upon the chosen agency, which agency shall have the largest practicable measure of freedom in carrying out the project.

8 The Foundation will require periodically an accounting for resources supplied for each project and acceptable reports of results.

9 Proposals recommended by its Founder Societies and of broad interest to the profession will be given preference.

10 The Foundation will endeavor within its sphere of influence to prevent conflict of research activities and such duplication as would be wasteful.

The Langley Field Conference

THE Eleventh Annual Conference of the National Advisory Committee for Aeronautics, held at Langley Field, Virginia, May 22, was as well attended, as interesting, and as informative as ever. True, no miracles, of research were disclosed, but perhaps the days of miracles in aeronautical research are past and steady improvement and refinement are now the more likely pathways of advance.

The Committee never fails, thanks to its generous resources, to exhibit at least one remarkable piece of new research equipment. This year the visitors were given the opportunity of seeing the world's largest high-speed tunnel in the final stages of construction. With stratosphere flight at enormous speeds in the offing, the problem of new airfoil and fuselage forms suitable for use at nearly the velocity of sound must be intensively studied. The new tunnel will give just the facilities required. The laboratory is equipped with an 8000-hp motor, a 16-ft, 18-bladed propeller, and will be capable of a speed of 500 mph. As the high speed means a great transformation of pressure into kinetic energy, the static pressure inside the tunnel is only 800 lb per sq ft as compared with the normal atmospheric pressure of 2117 lb per sq ft. To prevent caving-in of the channel, concrete walls of 12-in. thickness reinforced with steel plates half an inch thick are employed. The transformation of skin friction into heat obliged the designers to use a special cooling system acting on the walls. The automatic six-component balance, with photographic recording will have sensitivity enough to measure drags of a fraction of a pound, and power enough to record a lift of 5 tons.

Rivets on the under side of a huge flying-boat hull may appear insignificant, but they increase the hydrodynamic resistance at take-off by 25 per cent, which may make a real difference to the take-off characteristics of a heavily loaded flying boat designed for transoceanic use.

Hydrofoils used in conjunction with a hull were shown to reduce the drag a very large extent. Seaplane engineers have fought shy of hydrofoils on practical grounds—they may have to turn to this device in the future.

The aircraft gasoline engine is forging ahead, and with fuels of 100-octane rating, gives truly phenomenal results in power and fuel economy. But the new single-cylinder aircraft Diesel demonstrated by the Committee will give the Diesel exponents some ammunition.

Tapered wings should stall or break down in flow at the center, according to theory. The "contrariness" of nature makes the tips stall first, diminishing the efficiency of the ailerons and facilitating autorotation. By giving the tips a greater camber these undesirable features may be eliminated.

An entirely new engine cowling, the "nose cowling" made its appearance with visitors pledged to secrecy regarding its design. A secret held by hundreds of people is not so very secret.

The *Hindenburg* is here, and the Airship Survey Committee reports favorably on rigid airships. It is an interesting fact that the Committee is actively continuing its researches on the aerodynamics of airships. The *Macon* in a side wind of 60 deg and a velocity of 20 mph experiences a lateral force of 65,000 lb which makes the design of mechanical ground handling devices intelligible.

Gusts on air transports flying over flat country may cause accelerations of 3.5 times gravity. No wonder passengers may sometimes feel uncomfortable, even though no gust ever imposes loads as violent as those of

rapid maneuvers, so that structural failure in rough weather need never be feared.

[The foregoing report was prepared by Prof. A. Klemin, vice-chairman of the Aeronautic Division of The American Society of Mechanical Engineers, and official representative of the Society at the Langley Field Conference.—EDITOR.]

Award to Be Made for Book on Science Subject

A CASH award of $1000 is offered by The Williams & Wilkins Company for the best manuscript on a science subject, presented before July 1, 1937.

The publishers put no limitations on the subject matter or manner of handling, and none on eligibility for the award. The manuscript must be in English and "of a sort calculated to appeal to the taste of the public at large." The desired length is 100,000 words.

While any manuscript on a science subject will be considered, it is expected that the author will prove to be a man or woman engaged in a scientific pursuit and who is possessed of the requisite literary skill to interpret science for that portion of the public which reads books.

To assure authenticity, the publishers have enlisted the services of some 25 or 30 "advisers," these being men of science of wide reputation and assured competence. One or more of the advisers will pass upon each manuscript from the viewpoint of soundness and accuracy.

The award will lie in the joint discretion of four judges selected with a view to their especial qualification in choosing the sort of book that will appeal. These are:

Dr. Joseph Wheeler, librarian of the Pratt Library in Baltimore, and chairman of the Book List Committee of the Association for the Advancement of Science; Harry Hansen, reviewer and critic for the New York *World Telegram* and *Harpers Magazine*; Dr. Lyman Bryson, professor of education of Teachers College, Columbia University, and director of the "Readability Laboratory;" and David Dietz, science editor of the Scripps-Howard newspapers.

Iron and Steel Engineers Meet in Detroit, Sept. 22–25

THE 32nd convention and Iron and Steel Exposition of the Association of Iron and Steel Engineers will be held in Detroit, Mich., Sept. 22–25.

Among the features of this coming convention will be trips to the Ford Motor Company and the Great Lakes Steel Corporation.

At the present time the Iron and Steel Exposition which is held concurrently with the annual meeting promises to be one of the largest ever sponsored by the Society. Already 98 per cent of the space has been reserved by 125 manufacturers of steel-mill equipment which indicates that it will no doubt be necessary to arrange for additional space to take care of the unusual demand.

Silver Bay Industrial Relations Conference, Lake George, August 19–22

ANNOUNCEMENT has been received of the Nineteenth Annual Conference on Industrial Relations, to be held at Silver Bay on Lake George, N. Y., August 19–22, 1936. The conference is being conducted under the auspices of the Industrial Department of the National Council of Y.M.C.A.'s.

The theme of this year's conference is "Planning for Statesmanship in Human Relations in Industry," and the topics for discussion include the social and economic obligations of industry to the employee, to the public, and to stockholders; social-security legislation problems; current industrial problems arising out of transition from depression to prosperity conditions; and thrift plans.

Further information may be obtained from the executive secretary of the Conference, E. C. Worman, 347 Madison Ave., New York.

H. A. Schwartz Honored

HARRY A. SCHWARTZ, member, A.S.M.E., and manager of research, National Malleable and Steel Castings Company, Cleveland, Ohio, received the honorary degree of Doctor of Engineering at the 52nd commencement, June 1, 1936, of The Case School of Applied Science. Mr. Schwartz delivered the annual Sigma Xi lecture before the Case chapter on May 29 on "Our Debt to Josiah Willard Gibbs."

A.G.A.-A.S.M.E. Orifice-Coefficient Report to Be Published

ON SEPT. 25, 1931, a meeting of the Special Research Committee on Fluid Meters of The American Society of Mechanical Engineers and of the Natural Gas Department of the American Gas Association was held in Pittsburgh. The purpose of this meeting was to attempt to reach some agreement between the two organizations as to the types of orifices to be used for metering gases and other fluids and to determine the constants to be used in calculating the flow through these orifices. The outcome of this meeting was the appointment of a joint subcommittee of six members, three from each of the parent committees, to study the material then available on orifice meters, to supervise any additional research found necessary, and to prepare a report containing the necessary recommendations for the construction and installation of pipe orifices and the constants for use with them which would permit the metering of all fluids with a maximum commercial accuracy, and with consistent results with all types of orifices and pressure taps in common use.

This joint committee has completed this phase of its work and a report covering the results of its investigations was presented to the A.S.M.E. Special Research Committee on Fluid Meters at its meeting on Dec. 6, 1935.

The report consists of about 55 double-sized pages of history and conclusions, and is accompanied by an appendix containing 400 pages of data substantiating the findings of the report. It is the purpose of this article to furnish a short abstract of this report.

RÉSUMÉ OF THE REPORT

The first few pages are filled with a history of the orifice meter in this country, giving the early beginnings of the uses of this type of meter. This is followed by a short description of the organization and functions of the various committees and groups interested in the use of the meters, and the history of their growth and development. These organizations and the data of their foundation were as follows: The A.S.M.E. Special Research Committee on Fluid Meters (1915); The National Bureau of Standards (1919); The American Gas Association Committee on the Measurement of Large Volumes of Gas (1923); The Gas Measurement Committee, Natural Gas Association (1924); and the Joint Committee previously mentioned (1931).

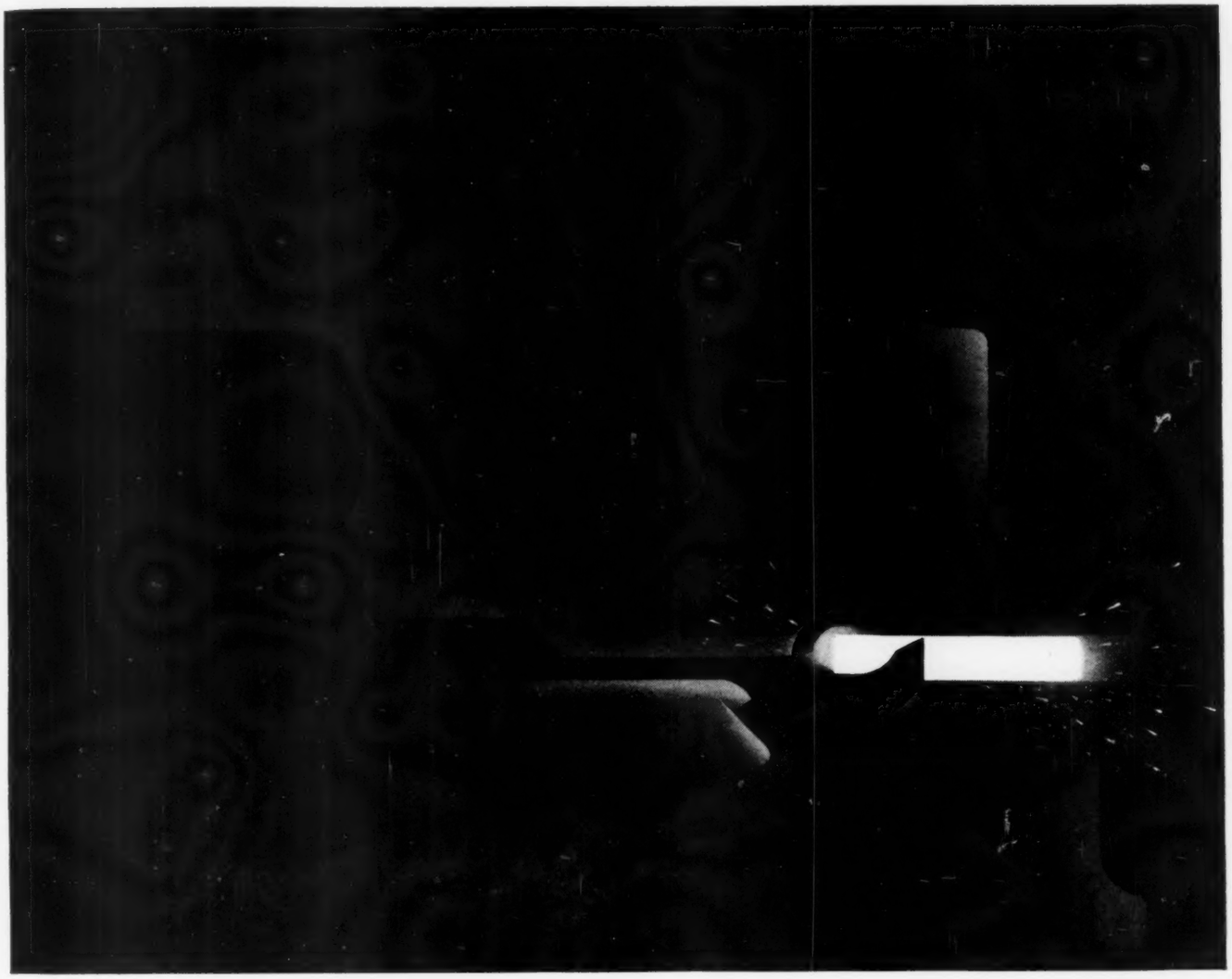
A short résumé of the various researches conducted by the committees and other interested bodies follows. The first of these were the tests by H. Judd in 1915, and there are outlined the work of a total of 21 different investigations of major importance.

There follows in the fourth section of the report the story of the analysis of the data available. This analysis was made for the committee by Buckingham and Bean of the National Bureau of Standards, and R. E. Sprenkle and S. R. Beitler. The final analyses are given in the formulas supplied by the National Bureau of Standards, which were adopted by the committee for use with flange and pipe taps, these being the taps most used in the measurement of natural gas, and in the form of curves for use with vena-contracta taps, which are the taps most used in the measurement of steam and water. These analyses are all based on the data secured for the committee by tests conducted at Ohio State University from January, 1932, to March, 1934. These tests were made to secure simultaneous data on flange, pipe, vena-contracta, throat, and corner taps, and covered a range of pipe sizes of from 1 to 14 in. in diameter. Formulas are also given in the analysis to calculate the coefficients of discharge for throat and corner taps. The committee did not make any recommendation with respect to the use of these taps as they are not in common commercial use in the United States and the committee did not feel that it should spend its time and effort in setting up recommendations which had no immediate practical value.

This section also contains the expansion factors to be applied to the liquid coefficients of orifices when metering compressible fluids like gases and steam. These expansion factors are computed from empirical formulas developed by Dr. Buckingham and Mr. Bean from the results of the Los Angeles tests supplemented by some of the results of other groups of tests.

All of the formulas and curves given in this section have been checked by comparison with all available data bearing on that part

(*Continued on page 470*)



For forgings that dare not fail—MOLY steels are best

AIRCRAFT construction demands the very utmost in steel dependability. . . . Forgings get the most meticulous inspection. Seams or blemishes too small to be detected by the naked eye are enough to cause rejection.

Chrome-Molybdenum (SAE 4130x) steel forgings have repeatedly proved themselves able to pass the most rigid tests with a minimum of rejects. They reduce machining costs as well.

This characteristic is true of all Molybdenum steels used for forgings. . . . Reject percentages, material costs and labor costs—all are lower, while the quality of the forgings is uniformly high.

Whether or not your forging requirements call for close inspection, it will pay you to investigate Moly steels. Write for our helpful technical book, "Molybdenum." On request, we will also gladly put you on the mailing list of our news-sheet, "The Moly Matrix." And if you are interested further—in some particular ferrous problem, for instance—our experimental laboratory facilities are at your disposal. Climax Molybdenum Company, 500 Fifth Ave., N. Y.

CUTS COSTS [illegible] SALES

MOLY

of the study and found to be well within the expected accuracy of test and computation.

The fifth section contains the committee's recommendations on the proper methods of constructing and installing concentric orifices. For this purpose it was pointed out that there were two different classes of orifice meters in common use, and that different sets of rules would have to be set up for the two classes. The first class consists of meters as ordinarily installed in power plants and water works where the orifice plate is permanently installed as part of the piping and where there is little likelihood that the size of the orifice will have to be changed. The second class includes meters in which the size of the orifice plate may be changed frequently to meet changes in seasonal and industrial conditions. Meters used in the measurement of fuel gas and purchased steam are in this class.

Certain of the specifications as to sharpness of edge and thickness of orifice plates, upstream and downstream pipe conditions, and size and location of pressure taps apply to both classes of meters and are so listed. For meters of the second class it was thought best to suggest certain standards for orifice fittings and sizes of plate in order to make for interchangeability.

No mention was made of secondary or head-measuring devices, pressure-measuring devices, or temperature-measuring devices, or their connections, except as they might affect the orifice plate and its coefficient, as this was not considered a function of the committee.

The sixth section gives a general discussion of the precautions to be observed in the use of orifices as metering devices and the accuracy to be expected under most conditions of installation. In addition, a statement of the expected tolerance of the various calculated factors is given and explained.

A short discussion of the effect of some of the factors not usually considered in orifice measurements follows, and the effect of not taking them into account is given. In addition there is a paragraph on the effect of pulsating flow on the measurements by an orifice.

The final section of the report is made up of tables and curves of orifice coefficients. The tables give the coefficients of discharge for concentric orifices in pipes of from 2 to 14 in. in diameter for ranges of diameter ratio of from 0.1 to 0.7 and for Reynolds numbers of from 10,000 to infinity, calculated from the formula given in section four, for flange and pipe taps. The curves give the coefficient values for vena-contracta taps for pipe sizes of from 2 to 14 in. for diameter ratios of from $7\frac{1}{2}$ to $82\frac{1}{2}$ per cent, and for Reynolds number values of from 10,000 to 2,000,000.

The appendix which accompanies the original report gives enough of the original data from the tests, made by or for the committee, for any one to check the committee's results, should they so desire.

Thus this report is not only based on, but presents most of the available data, of merit, from tests on orifice meters made in the United States during recent years. As it gives both orifice coefficients and instructions for installing and using orifice meters, the report should be of much assistance to any one interested in measuring fluid rates of flow.

It is planned to publish the report, without the appendix containing the data, as soon as the number of copies can be estimated from advance orders. It is expected that the price will be $2.75 per copy. Orders and inquiries should be addressed to Publication Sales Dept., A.S.M.E., 29 West 39th St., New York, N. Y.

Welding Practice Symposium Cleveland, October 22–23

A WELDING-practice symposium will be held in Cleveland, Ohio, October 22–23, 1936, at the Hotel Cleveland. This meeting is being held jointly with the American Welding Society. The Cleveland Section of The American Society of Mechanical Engineers is sponsoring the local arrangements with the local committee of the American Welding Society.

There will be joint sessions with the American Welding Society on Thursday October 22 and these will cover stress analysis, alloy steel and its weldability, and the welding of heavy machinery. Thursday night a dinner is planned with the Welding Society, and on Friday the Welding Society will cooperate in the A.S.M.E. program, which will consist of a session on Friday morning on weldability of nonferrous metals and a session on Friday afternoon which will include a review of welding development, welding of light products, and the principles involved in selecting castings and welding.

N. R. Gibson Appointed to N. Y. State Board of Examiners

NORMAN R. GIBSON, member, A.S.M.E. and vice-president and chief engineer, Niagara Falls Power Co., Niagara Falls, N. Y., has been appointed a member of the New York State Board of Examiners.

A.E.C. News From Washington

THERE are at present in Washington two movements which tend, in part, to offset each other, but about which much will no doubt be heard during the next few months. On the one hand, are groups of men within and without the government working on new plans for federal bureaus or departments which will take over the work of the emergency agencies which have, for one reason or the other, been dropped. For example, a number of plans are underway for the revival of the NRA on some new legal base. Some of the new plans take the form of setting up an overall agency similar to the old NRA, and others take the form of special legislation such as the Ellenbogen Bill for the control of the textile industry, which in essence is a "little NRA;" the Guffey Bill for the control of the coal industry is similar in purpose. Recent decisions of the Supreme Court have made the legal basis for these various new plans problematical, nevertheless, plans are under discussion to introduce in the next Congress forms of legislation which will meet the constitutional requirements.

Hand in hand with these activities, which if carried out will further increase the number and complexity of the government operations, three committees have been appointed to consider the possibility of consolidaton and simplification of government organization; one by the Senate, one by the House and a third by the President.

The Senate Committee appointed an Advisory Committee made up as follows: Dr. Louis Brownlow, Dr. Luther Gulick, Hon. Wm. Tudor Gardiner, Boston, former governor of Maine; Dr. H. W. Dodds, President of Princeton University, and Dr. John D. Clark, of Cheyenne, Wyoming, professor of economics at the University of Denver, Colo.

President Roosevelt requested the same men to act as an advisory committee to his special committee which is now called "The President's Committee on Administrative Management." Senator Byrd's committee has requested the Brookings Institution to present a plan of procedure for his committee. The House Committee has not yet reported any course of action. The President's Committee has appointed a number of university professors expert in government organization to make surveys and studies, although the method of paying for this work is not finally settled. There is some confusion at the moment as to the common objectives of these interrelated committees, but in all probability the advisory committee will resolve these overlapping responsibilities. Meanwhile the staff of American Engineering Council has been requested by the President's Committee to confer with its staff and make suggestions and the Brookings Institution has been provided with recommendations of earlier committees of the Council with reference particularly to public works administration, mapping, and water resources.

RURAL ELECTRIFICATION

Rural Electrification Administration now has a permanent status. It reports accelerated expansion of loans to both private utilities and cooperatives, but the total loans in the first year for the entire 76 projects involving approximately 12,000 miles of line to serve about 40,000 customers in 25 states was only $12,331,412. That is a good start but it indicates that citizens in rural areas are slow to obligate themselves, even through cooperatives, to liquidate relatively large loans for power lines and hesitate to commit themselves to the direct purchase and installation of electrification for their individual homes.

Since R.E.A. funds are only advanced to sponsors as economic, legal, and engineering requirements are satisfied, it must be admitted that the services of practical engineers are essential to the success of the program. Speaking about the situation, Administrator Morris L. Cooke says, "It requires a new type of engineer—a rural engineer—who is intimately acquainted with the practical problems that the farmer has to face and can make practical

(*Continued on page 472*)

Avoid the High Cost of Scored and Worn Pump Shafts

AND STILL MAINTAIN A TIGHT STUFFING-BOX WITHOUT FRICTION.

SQUARE
PALCO
PLAITED PACKING

SOLVES THE PROBLEM

as it carries in each single strand an abundance of graphite-grease lubricant that keeps the shaft constantly lubricated.

"PALCO" GIVES LONGER SERVICE IN CENTRIFUGAL PUMPS THAN INSUFFICIENTLY LUBRICATED PACKINGS.

Let us send you without obligation a working sample of "PALCO" to test out under your own conditions. State size required for test.

GREENE, TWEED & CO.
SOLE MANUFACTURERS
109 DUANE STREET, NEW YORK

suggestions which will stand the rough test of experience."

ENGINEERING EMPLOYMENT SITUATION

All engineers seeking employment should know that there is an excess of engineers, as well as other employees at this time, in government service. Many are kept on government payrolls as long as funds are available to provide them with a subsistence until they can find an opportunity to make a living some where else. It is not the case in the permanent agencies and it is not so true in regional, state, and local offices but much of it is being done in the emergency agencies.

A very few vacancies are available at almost all times, but there is keen competition among engineers in the service as well as from the outside for them. Those on the inside have the advantage of experience and the influence of personal acquaintances, even though they may not be as well qualified for the positions.

The most promising prospect, at this time, for the expansion of engineering employment in government service is with the Rural Electrification Administration. Most of the opportunities will be with the borrowing bodies in those states participating in the programs and with contractors and supply houses who go after rural electrification business.

It is obvious, however, that many engineers in government service will soon have to find work in private employment and practice, and it is evident that those who are first to make the change are likely to get the better opportunities. On that premise, it is suggested that engineers rise above the current storm of political confusion and observe that their training and experience is admittedly essential in the modernization of business and industry to bring about the necessary economic balance between production, distribution, and consumption. The need is not confined to engineering in the technical sense. The steel and automotive industries have found it most advantageous to have engineers in management and in the councils of the directors influencing policies and objectives. Business and industrial executives returning to the active and profitable mental working status attained in the early days of their careers are taking competent engineer executives who can overcome unusual difficulties into their official families because they realize that such responsibilities should not be left to hired subordinates.

SURVEY OF ENGINEERS

The June number of the *Monthly Labor Review*, published by the U. S. Department of Labor and issued the third week of this month, will contain the first summary of the statistics from the "Survey of Engineers" conducted in August and September, 1935, by the Bureau of Labor Statistics under the supervision of the Committee on Engineering and Allied Technical Profession of the American Engineering Council in cooperation with more than 100 national, state, and local engineering societies. More than 60 thousand questionnaires were returned to the Bureau of Labor Statistics for classification and codification. This is the first professional survey undertaken by the Bureau of Labor Statistics and the returns represent the largest sampling of the engineering profession ever made.

This article summarizes, briefly, the number of engineers in each of the branches of the profession, where they were employed as between government and private industry, and the interrelation between their educational training and the positions held. Reprints of this article will be available about the first of July.

The final bulletin will present a very comprehensive analysis of the profession, including facts on education, distribution of engineers in both government and private employment, compensation, and a very complete picture of the engineering employment conditions for the period between 1929 and 1934. It is hoped that the final bulletin will be available in the early fall.

Dr. Isador Lubin, Commissioner of Labor Statistics, U. S. Department of Labor, presented a paper on the results of the survey at the Madison Meeting of S.P.E.E. in June in which facts with regard to employment conditions and compensation with particular reference to the period from 1929 to 1934 will be covered. It is expected that Dr. Lubin's address will be available for distribution in July.

Törnebohm-Kamo Luncheon

ON June 3, members of the Executive Committee of Council of The American Society of Mechanical Engineers, the Committee on Meetings and Program, and other engineers were present at a luncheon, at the Engineers' Club, New York, N. Y., given in honor of Hilding Törnebohm, who is chief engineer of the A. B. Svenska Kullagerfabriken, Goteborg, Sweden, and Calvin W. Rice Memorial lecturer at Dallas, Texas, June 17, and Dr. Masawo Kamo, of Tokyo, Japan, honorary member, A.S.M.E., and professor of mechanical engineering, Tokyo Imperial University. Doctor Kamo is en route to technical meetings in Europe.

President Batt presided at the luncheon and introduced the guests of honor. Doctor Kamo spoke with deep feeling of his sense of loss in the death of former Secretary Calvin W. Rice. Mr. Törnebohm expressed his satisfaction at being able to visit this country and at the opportunity his visit afforded of meeting personally many engineers who were known to him through their published work.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after July 25, 1936, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

COTHER, A. A., Novosibersk, Siberia, U.S.S.R.
DOLAN, THOMAS J., Urbana, Ill.
FARRELL, EUGENE F., Detroit, Mich.
FAULKNER, CARLOS L., Atlanta, Ga.
JARMOLOW, BENJ., Brooklyn, N. Y.
MCCLURE, LEWIS S., Berkeley, Calif.
MERCIER, STANLEY M., Boston, Mass.
NASH, WILLIAM W., Aurora, Ill.
NUGENT, E. L., Detroit, Mich.
PAMPHILON, G. M., Burlingame, Calif.
PAREKH, G. D., Benares City, India
RIDDELL, JAMES, Detroit, Mich.
ROTHE, HUGO F. W., Warren, Pa.
SACHITHANANDAM, N., Madras, India
SCHAEFER, HENRY, Tulsa, Okla.
SCHUCANY, O. W., Dallas, Tex.
STANGELAND, OLE I., Chicago, Ill.
THOMSON, H. W., South Gate, Calif.
VARADY, JOHN C., Clarksburg, W. Va.
WEBER, PROF. ANDREW R., Dayton, Ohio

CHANGE OF GRADING

Transfers from Junior

AHARA, E. V., Rumford, Maine
BRESCKA, RUDOLPH S., Cranford, N. J.
ELLIOTT, ROBERT F., Jersey City, N. J.
SHAW, BURTON E., Adel, Iowa

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

BOGART, A. N., May 23, 1936
CASHEN, HENRY C., May 19, 1936
ENGEL, GODFREY, SR., May 29, 1936
HAMMOND, JOHN HAYS, June 8, 1936
HIRSCHLER, HORACE L., May 24, 1936
LYLES, LEONARD C., May 6, 1936
PATTERSON, WM. C., JR., May 14, 1936
SPINOSA, SALVATORE, May 6, 1936
WAITE, C. L., April 11, 1936
WOODCOCK, WILLARD J., April 2, 1936
WROE, WM. CLARKE, May 18, 1936

A.S.M.E. Transactions for June, 1936

THE June, 1936, issue of the Transactions of the A.S.M.E., the *Journal of Applied Mechanics*, contains the following papers:

TECHNICAL PAPERS

An Experimental Towing Tank for Small Models, by K. S. M. Davidson
Stability of Rectangular Plates Elastically Supported at the Edges, by A. J. Miles
Third Moments, by R. C. Yates
Impact on Beams, by H. L. Mason
A Method of Analyzing Creep Data, by R. G. Sturm, C. Dumont, and F. M. Howell

RESEARCH REVIEW

Review of Research in Strength of Materials, by F. L. Everett and J. L. Maulbetsch

DESIGN DATA

Stress and Deflection of Rectangular Plates, by I. A. Wojtaszak

DISCUSSION

On previously published paper by O. J. Horger

BOOK REVIEWS

By A. T. Ippen; J. C. Hunsaker; A. L. Kimball; G. B. Pegram; C. R. Soderberg; M. D. Hersey; J. L. Maulbetsch; and E. S. Dennison